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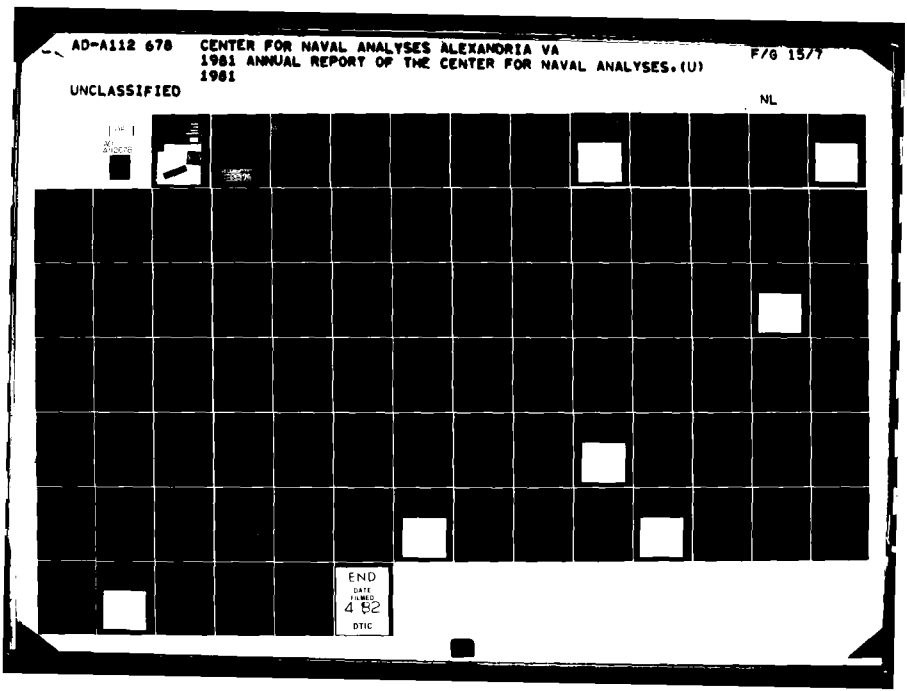

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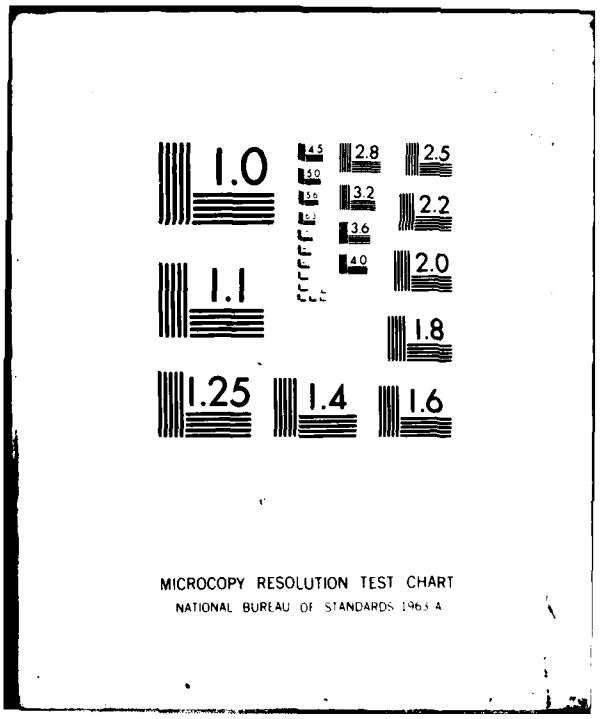
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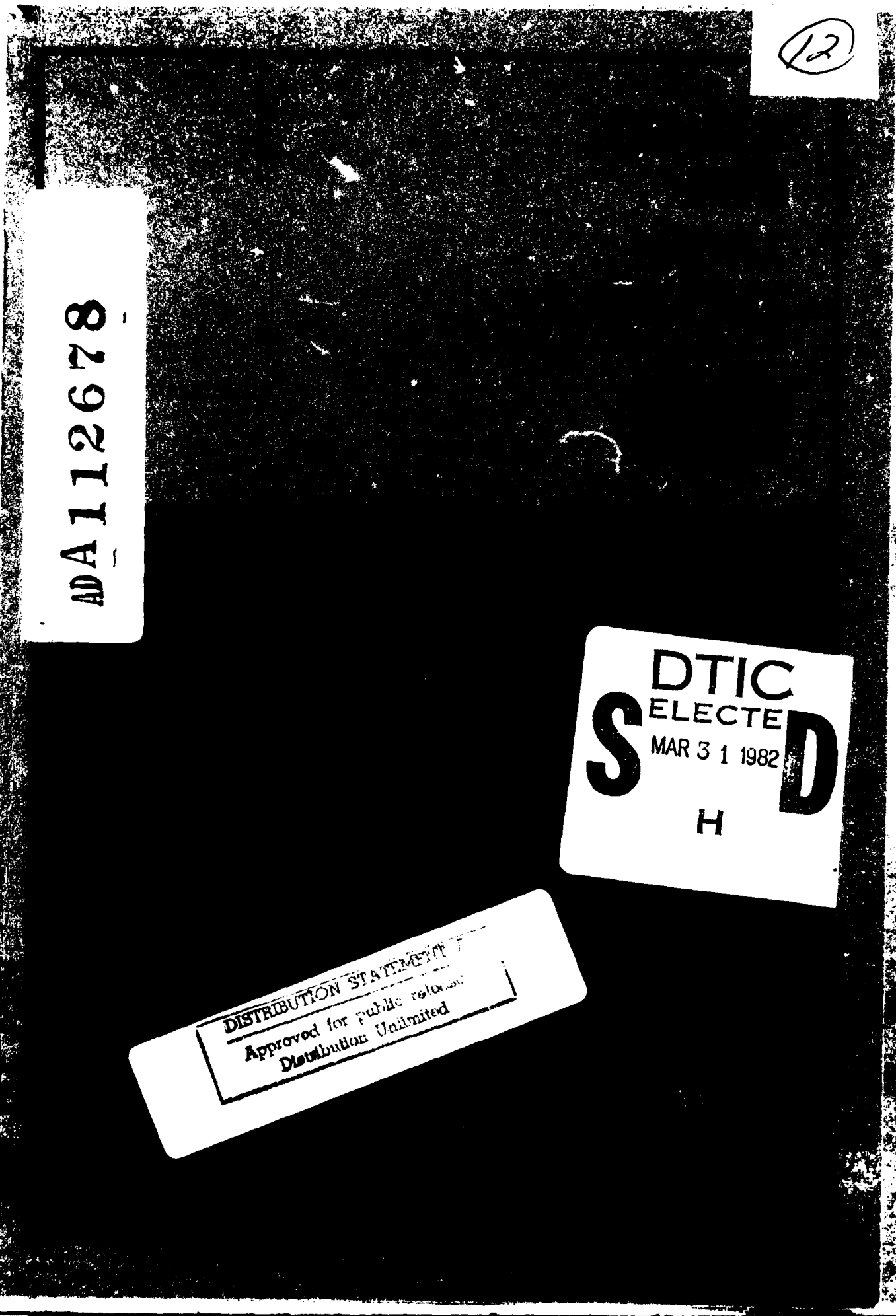
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1. The Board of Overseers of the Center for Naval Analyses publishes a report each year on the work of CNA. This year's report [enclosure (1)] reviews CNA's research and its use of Government resources from 1 October 1980 through 30 September 1981.

2. As this year's report appears in print, CNA marks its twentieth anniversary. Accordingly, the report includes a discussion of CNA's contributions to the nation's defense, since 1962. The description of CNA's work attests to the Center's expertise in naval matters and its ability to anticipate and analyze problems of national importance.

3. The Navy and Marine Corps continue to be well served by CNA.

C. A. H. Trost

C. A. H. TROST
VICE ADMIRAL, U.S. NAVY
DIRECTOR, NAVY PROGRAM PLANNING

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CENTER FOR NAVAL ANALYSES

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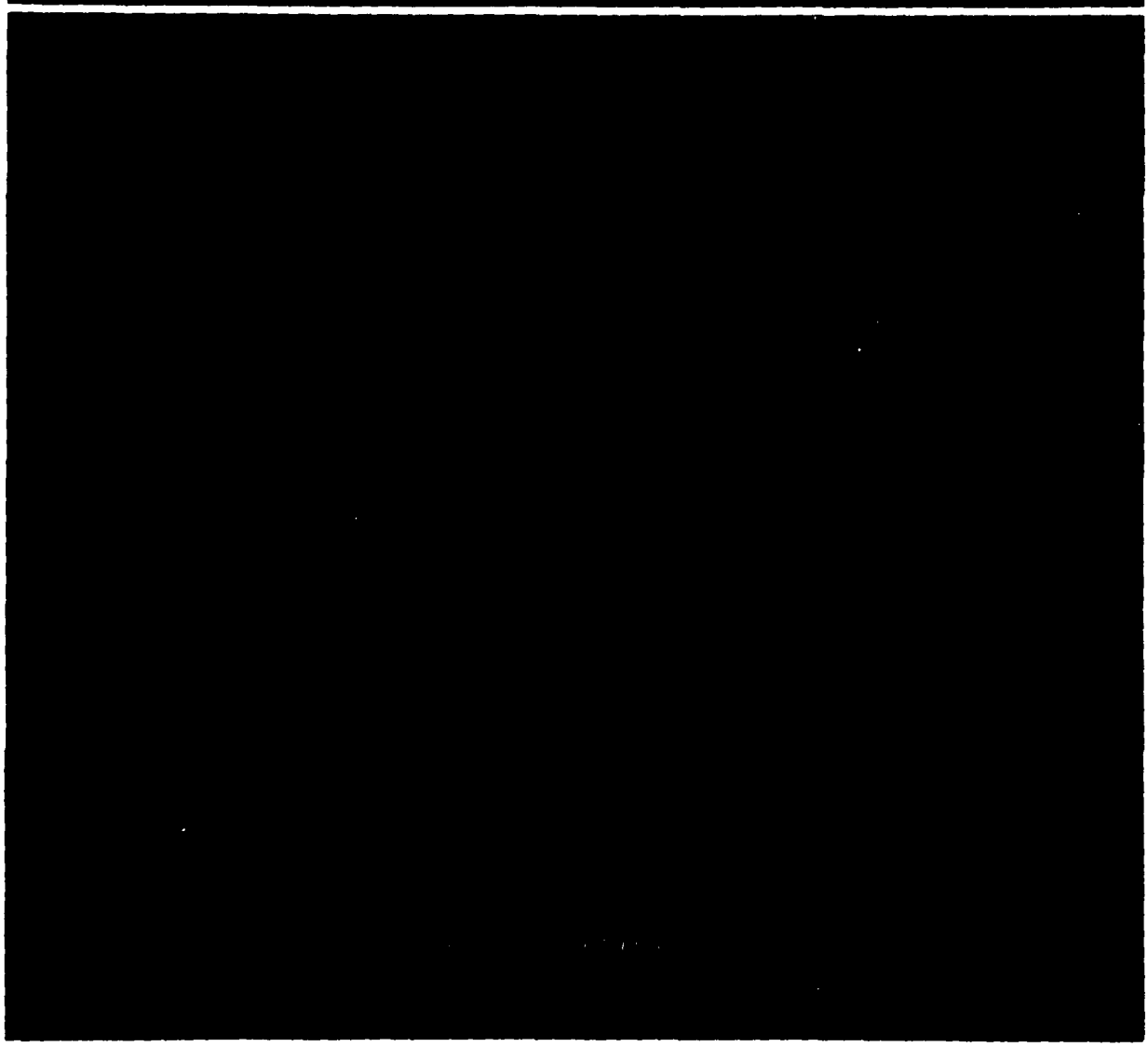
ANNUAL REPORT 1981



FOREWORD

As this report appears in print, the Center for Naval Analyses nears its twentieth anniversary. CNA was formed on the first day of July 1962, when the Operations Evaluation Group and the Institute of Naval Studies – the one concerned with current naval capabilities, the other with the Navy's options for the future – were placed under one management.

Since 1967, the University of Rochester has been responsible for management of the Center. The University's contractual agreement with the Navy Department has assured the independence of CNA's research, while preserving the close ties between the Navy and CNA that are essential to pertinent, informed research. Through its accumulation of expertise in naval strategy, forces, operations, and support activities, CNA has often been able to anticipate and analyze problems before they become urgent.

However, there is always the danger that analysis will fall into set patterns, thus increasing the chance that important problems will not be anticipated and dealt with. In 1981, therefore, the CNA management began a careful review of the Center's research activities and organization. In its review, CNA management has sought the views of informed outsiders, as well as the views of the Navy, the Marine Corps, and CNA staff members.

A major change resulting from the review is the refocusing of CNA's program of Navy studies, to give more attention to advanced technology, long-range Navy planning, the course and conduct of future naval warfare, and Navy management procedures – while continuing to do research in strategy, force capabilities and options, manpower, logistics, and readiness. Studies in all areas will deal more with underlying policy options than with transitory program issues.

To facilitate this wider-ranging program of research, the Institute of Naval Studies and Naval Warfare Analysis Group have been consolidated to form the Naval Studies Group. The new group consists of seven research programs: Naval Strategy; Advanced Technology; Long-Term Force Planning; Naval Warfare; Manpower, Support, and Readiness; Management Processes; and a Special Studies program for defense studies done under contracts other than CNA's prime contract with the Navy Department.

For these programs, CNA has attracted able and experienced directors. They will work with small advisory groups in shaping their programs. Each advisory group will include a member of CNA's Board of Overseers, a highly qualified former military leader, a civilian representative from the appropriate Navy research community, and recognized experts from academia and industry. The advisory councils will play an important role in linking CNA to sources of new ideas and new information.

To disseminate the results of CNA's research more broadly, annual conferences will be held by all of the research programs within CNA's operating groups – the Naval Studies Group, Operations Evaluation Group, and Marine Corps Operations Analysis Group. The conferences will bring together managers and analysts from the Navy and Marine Corps, CNA researchers, and outside experts. CNA's research will thus be made available to a wide audience of potential users, will be informed by the research of others, and will deal with the most important policy issues facing the Navy and Marine Corps.

Another result of the 1981 review is a simpler management structure for CNA. The management staff has been reduced from thirteen members to five: the President, the Vice Presidents in charge of the operating groups, and the Vice President for Finance and Administration. This change allows the directors of the research programs within the operating groups to concentrate on research.

One change was made in the membership of CNA's Board of Overseers in 1981. David S. Potter, vice president in charge of public relations for the General Motors Corporation, joined the Board. He succeeds Clarence L. A. Wynd, who retired from active membership. Mr. Wynd, a Board member since 1968, was elected to honorary membership.

David Kassing
President

W. Allen Wallis
Chairman of the Board

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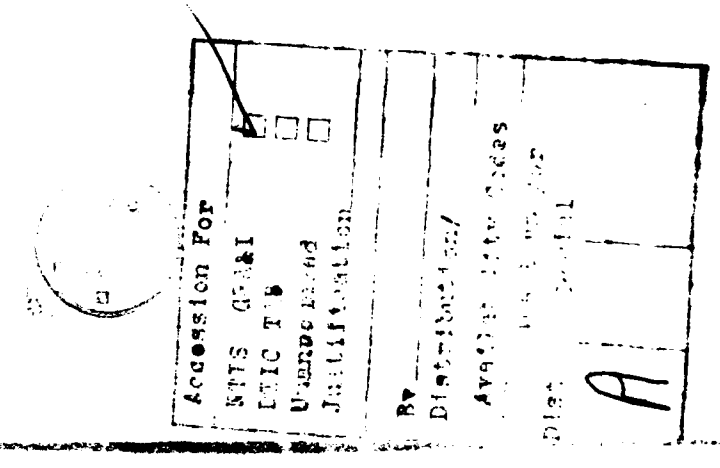
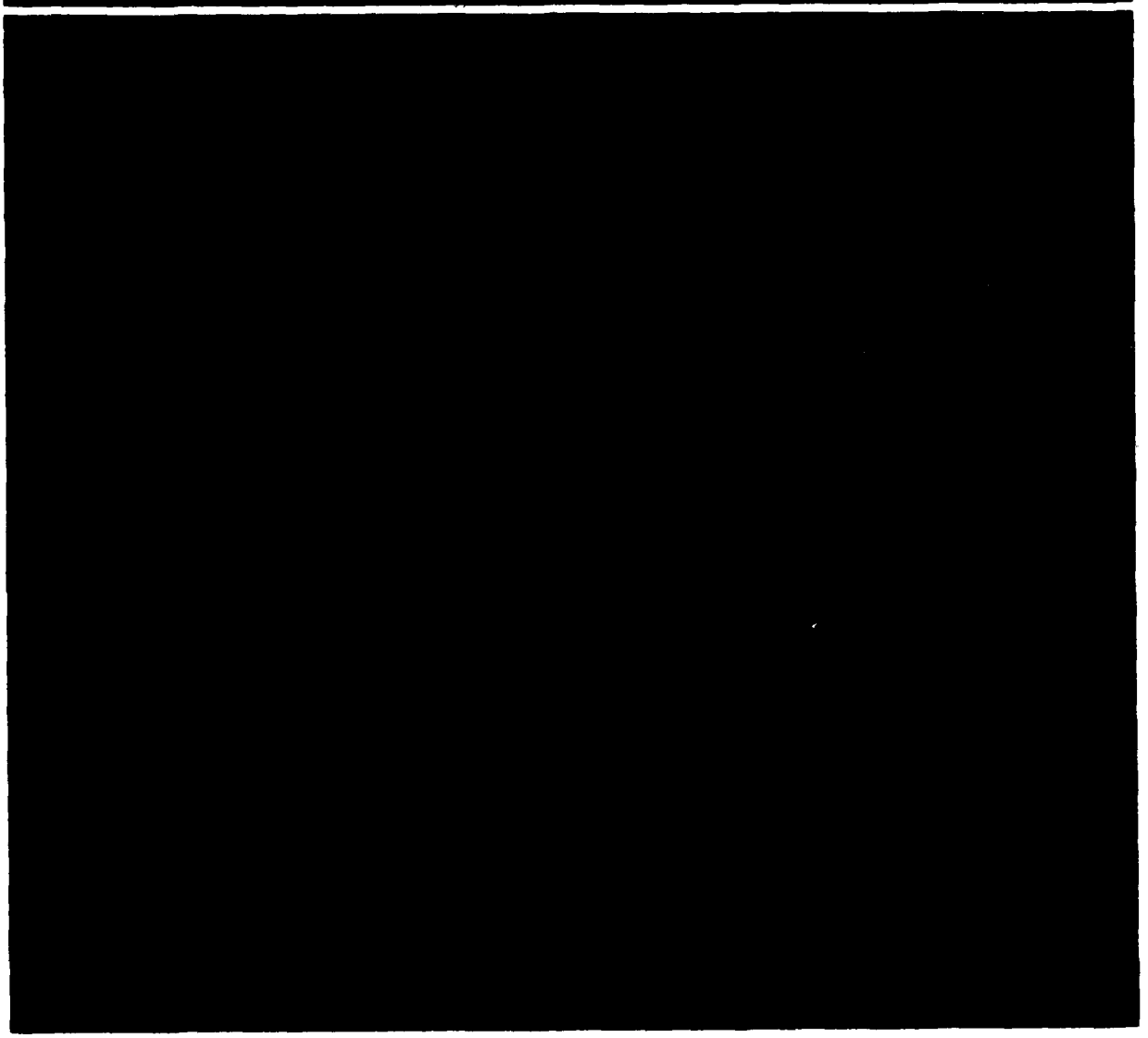


CNA: THE FIRST TWENTY YEARS



The history of CNA stretches beyond its formation in 1962-back to 1942, when the United States Navy established the Anti-Submarine Warfare Operations Research Group. By 1944, the group had so broadened its research activities that it became known simply as the Operations Research Group. The success of the group demonstrated the value of quantitative analysis of operational problems. As the war ended, therefore, the group continued as the Operations Evaluation Group (OEG). In 1962, OEG joined with the Institute of Naval Studies (INS) to form the Center for Naval Analyses.

OEG dealt mainly with current naval operations and ways to improve them. INS, by contrast, looked mainly to the future—asking what missions the Navy might have to perform, what kinds of forces might be required for those missions, and what new technologies might be exploited by the Navy of the future.

Since 1962, CNA has expanded its activities, studying a wider range of issues for the Navy, undertaking a regular program of research for the Marine Corps, and conducting studies for non-defense agencies of the government.

CNA's relations with the Navy Department have also changed. While maintaining the close ties to the Navy and Marine Corps that began with the formation of ASWORG in 1942, CNA—under the sponsorship of the University of Rochester—has acquired an extra measure of independence in the selection and conduct of its research. This independence has enabled CNA to anticipate, analyze, and propose solutions to many problems facing the Navy and Marine Corps, before the problems become intractable—sometimes before the services have fully realized their importance.

The rest of this section outlines the development of CNA since 1962, focuses on CNA's contributions, and sums up both the state of CNA today and its prospects for the future.

AN HISTORICAL OUTLINE

An administrative history of CNA's first twenty years may be roughly divided into four periods:

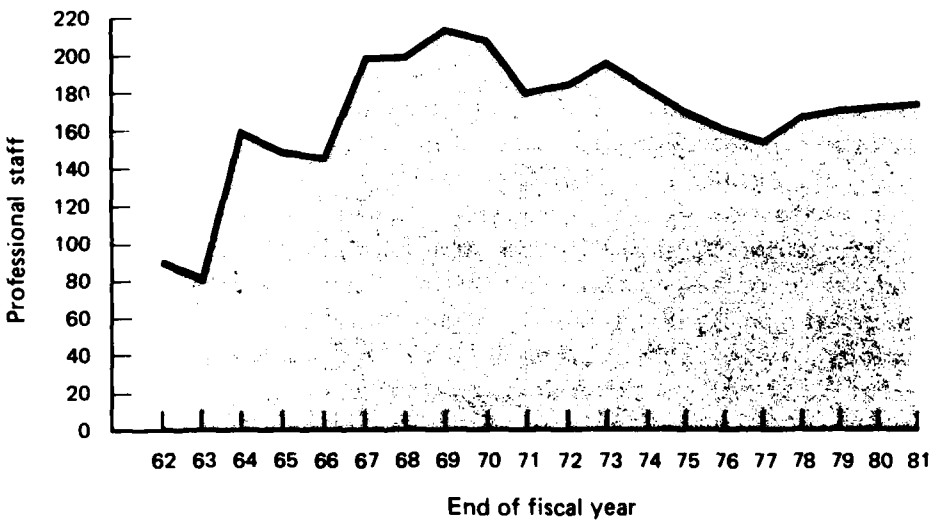
- 1962-67—early growth and expansion of research

- 1967-71—assumption of management by the University of Rochester, accompanied by further growth
- 1971-77—limited shrinkage in size, but not in scope of research, because of reductions in funding by Congress
- 1977-81—stability and reaffirmation of need for CNA.

1962-67

When the formation of CNA brought OEG and INS together under the management of the Franklin Institute of the State of Pennsylvania, CNA's professional staff numbered 90. By mid-1967, when the University of Rochester assumed management of the Center, the staff had grown to 200. (The figure below shows the size of CNA's professional staff from 1962 through 1981.)

SIZE OF CNA PROFESSIONAL STAFF
FY 1962 – FY 1981*



** Including analysts in non-defense research.*

Most of the growth came as a result of the emphasis placed on force level and force mix issues by Secretary of Defense McNamara. Assessments of the Navy's warfare capabilities five to ten years ahead were called for; the Navy and Marine Corps were required to submit

cost-effectiveness studies in support of their proposals for new weapon systems to be developed or procured within the next ten years. Accordingly, CNA enlarged the Naval Warfare Analysis Group (NAVWAG)—which had been part of OEG—and made it a separate group, and established the Systems Evaluation Group (SEG) and Marine Corps Operations Analysis Group (MCOAG).

If studies of future warfare and weapons are to be realistic they must be grounded in operational data. The analyses conducted by OEG therefore became as important to the new components of CNA as they had always been to the fleet. Many OEG analysts—with years of "hands on" experience gained in field assignments with the fleet—became leaders and members of study teams in the new research groups. MCOAG, too, established field billets at Marine Corps commands. CNA was developing the skills needed to help the Navy and Marine Corps answer the broader questions that Secretary McNamara was asking them.

By 1967, however, the Navy was looking for an institution that could better assure CNA's intellectual independence as it coped with these broader questions. The Navy believed that CNA had to attract and retain a staff of higher quality, to turn out more deeply analytical and timely studies, and to show a greater willingness to challenge vested interests and "conventional wisdom"—within the Navy and outside it.

The Navy concluded that CNA should be managed by a university with the highest professional standards. The University of Rochester was approached, not only because of its academic reputation, but also because of its experience in managing research projects for the government. Moreover, key members of the University staff had held positions in the national security community and were experienced in analysis of defense problems.

1967-71

The University agreed to accept the responsibility, but only on condition that it have the right to manage CNA in a way consistent with University standards, particularly regarding intellectual independence. Because the Navy had already recognized the need for more intellectual independence, the stage was set for a unique con-

tractual agreement, which is still in effect. These are the key provisions to assure intellectual independence:

- Up to 23 percent of the annual funding can be used for research on Naval problems that CNA decides are important—over the Navy's objections if necessary.
- The remainder of the program must be agreed on by the Navy and the President of CNA. CNA need not accept any task it does not feel it should.
- Once agreed, the annual program can be changed by mutual consent only. The Navy cannot stop an analysis if it senses an unpalatable outcome.
- All analysis is done under the direction of the President of CNA. The Navy does not control the analytical process.
- If the Navy objects to the findings of a CNA project, it may state its position in a memorandum that is then bound into the report. But the Navy cannot suppress any CNA report or keep an analysis critical of the Navy from outside agencies.

In addition to fostering high standards of scientific, scholarly, and intellectual excellence, CNA's affiliation with the University of Rochester has helped CNA to improve the quality of its staff. In 1967, about 30 percent of CNA's professionals held doctorates: by 1971, the figure had risen to 40 percent.

During this period, an increasing number of analysts were assigned to OEG and MCOAG, the two groups that analyze current operations. With U.S. involvement in the Vietnam War, the Navy and Marine Corps asked for more analytical help, and CNA responded. New field billets were established, and more analysts at CNA-Washington were assigned to studies of Navy and Marine Corps operations in Southeast Asia.

Growth of the field program was also stimulated by CNA's acquisition of the Tactical Analysis Group (TAG), which became part of OEG in early 1971. At first, the program focused on antisubmarine warfare, specifically tactical and operational analyses for operating forces. Later, TAG became the analytical core of the Navy-wide Tactical Development and Evaluation program, and TAG research was broadened to include all types of naval warfare.

In 1970, the Secretary of Defense suggested that the talents and techniques that had been applied successfully to defense analysis by such organizations as CNA be applied to non-defense problems, as well. CNA responded by surveying the analytical needs of non-defense agencies of the government.

This groundwork led eventually to the establishment of the Public Research Institute (PRI) within CNA. PRI has worked on such subjects as the economic effects of pollution controls, the effects of imports on employment, the employment implications of technical progress, and the adequacy and economic effects of unemployment insurance systems.

1971-77

At the height of the widespread campus unrest during the Vietnam War, CNA came under attack from some students and faculty members of the University of Rochester. In that era, when compromise was a common expedient on many campuses, the University stood on principle, at considerable cost to itself, and refused to bow to demands for an end to the University's tie with CNA. The hostility that flared on the University campus was rooted primarily in the passions of the antiwar movement and, though once intense, died away with the war.

In the early and mid 1970s, however, Congress cut the budgets of CNA and other Federal Contract Research Centers a number of times. Inflation also forced reduction of CNA's professional staff. By 1977, the staff numbered 160—about the level of 1964-66.

The staffing cuts did not affect the types of research done by CNA as much as they did the number of analyses. For example, about eight fewer field representatives could be assigned to Navy commands.

Despite its tight budgets, CNA redoubled its emphasis on quality in its staff and research. The proportion of analysts holding doctorates rose from about 40 percent to more than 55 percent, and a more rigorous program of quality control was instituted.

Under the new quality control procedures, all reports of research are

reviewed in the operating groups and by a senior analyst who reports directly to the President of CNA, giving the President an independent assessment of the quality of research being produced.

1977-1981

The year 1977 began a period of relative stability for CNA. The interim report of the Navy Department's evaluation of CNA, which Congress had requested, gave high marks to CNA. The report covered CNA's Navy study program, its analyses of fleet operations, and its work for the Marine Corps.

The CNA program of Naval studies was found to be effective and economical, benefiting from "continuity, experience level, and protected objectivity." The fleet commanders, the report said, found that "the performance of OEG analysts is superior" in "quality, quantity, and responsiveness." Similarly, the Marine Corps found the work of MCOAG to be "timely and responsive," concluding that the research could not readily be duplicated elsewhere. CNA research was found to cost five to twelve percent less than similar research done in other organizations. These findings were confirmed in 1978, in the final report.

Timely completion of research began to receive special attention after the Navy Department's evaluation of CNA. The evaluation pointed out a CNA problem: difficulty in completing major studies on schedule. Though this problem plagues almost all study groups that do work of comparable complexity and difficulty, CNA's performance needed improvement. CNA therefore adopted these measures:

- CNA research managers increased their surveillance of the progress of every study toward its scheduled completion.
- Punctuality in meeting schedules now plays a more important part when the performance of individual staff members is evaluated.
- More studies are reviewed simultaneously by CNA and the Navy or Marine Corps. Though standards of quality of the final product are thus maintained, the customer has a chance to become familiar with the product sooner.

At least partly because of these measures, CNA published a third more formal reports per professional man-year in 1977-81 than in the preceding five years.

One organizational change was the merger of the Systems Evaluation Group into the Naval Warfare Analysis Group. The two groups had come to analyze similar types of problems regarding future Naval forces and weapons. It was time to pool their skills and knowledge.

The Naval Warfare Analysis Group and Institute of Naval Studies have since been combined to form the Naval Studies Group. The new group's program of research is described in section III; the aims of the consolidation are discussed later in this section.

AN ANALYTICAL PROFILE

The Navy allocates a smaller part of its budget to CNA than it does to the procurement of one fighter aircraft, for example. CNA's research may, however, influence the strategies to be served by all Naval forces, the number of forces bought, and their design, readiness for combat, and tactics. But CNA's analysis does not necessarily *determine* such things.

Choices of strategies, tactics, and budget allocations often hinge on facts that lie outside the reach of analysts, in the understanding and experience of decision-makers.

The influence of CNA's research is often subtle. A specific decision cannot always be tied to a specific analysis. What matters is whether CNA directs its skills toward the analysis of significant problems, whether CNA's analysis yields useful insights to decision-makers, and whether it possesses the independence and honesty to avoid pre-conceived answers.

The following survey suggests- though by no means exhausts- the breadth of CNA's first twenty years of research, the importance of the issues that CNA has addressed, and the originality of its insights into the issues.

Defense Research

Operations Analysis

The best test of strategies, tactics, and forces is how well they work in operation. Operational data, in turn, suggest better strategies, tactics, and forces. Operations analysis is thus of immediate value to commanders of Navy and Marine Corps forces, while it also informs many CNA studies of future options.

Over the years, about one-fourth of CNA's analysts have been assigned to operational, test, and experimental commands of the Navy and Marine Corps.

Another fourth of CNA's analysts are usually assigned to related projects at CNA-Washington. Field representatives and their colleagues in Washington help to assess current readiness and effectiveness, and they look for ways to improve both. They work on the development of tactics. To try out the latest concepts and equipment, they help to design exercises and then evaluate the results. In addition, they help with the final testing of new equipment, both to make sure it is ready for use and to find the best ways to use it. All this involves a wide variety of Navy and Marine Corps equipment, tactics, and operations—surface ships, submarines, aircraft, missiles, tanks, landing craft, communications, intelligence—and often the complex interrelationships among them.

Following the precedents of World War II and the Korean War, analysts in the field and in Washington made extensive studies of the Navy's operations in Southeast Asia from 1965 through 1972. They evaluated the performance of new aircraft and weapon systems, and they assessed the effectiveness of the naval campaign. A great deal of attention was paid to aircraft losses, particularly those exacted by ground defenses. Some of the analyses were translated into changes in tactics.

Some of the other research carried out by CNA field analysts for the Navy during the Vietnam War dealt with the recovery of downed aircrews, tracking of enemy aircraft, attacks by aircraft against transport of military supplies in North Vietnam, and air-to-air combat. For the Marine Corps, CNA's field analysts worked on patterns of enemy

ground attacks, casualties caused by mines and booby traps, reconnaissance patrol operations, and aircraft shelter requirements.

With the end of U.S. involvement in the Vietnam War, CNA's attention shifted to new challenges. For the Marine Corps, CNA field representatives planned and analyzed a series of tests to help select the aircraft for close air support of ground forces. CNA analysts in the field and Washington also worked with the Marine Corps to test and study the effects that changes in the organization and equipment of Marine Corps infantry battalions would be likely to have on their performance in combat.

In the fleet, CNA studied aircraft that can land and take off in a short distance or vertically (V/STOL), to see what opportunities and problems such aircraft may present in the fleet. A CNA analyst drafted the test plans for the first evaluation of V/STOL aircraft on an aircraft carrier and supplied analytical support throughout the evaluation. The analyst's report provided the Navy, Marine Corps, and aircraft industry with valuable insights into the use of V/STOL aircraft. The analyst also developed a model of V/STOL aircraft operations that was used in the CNA-Washington study of the costs and effectiveness of alternative forces of sea-based aircraft and the ships that carry them.

Soviet submarines armed with cruise missiles pose a formidable threat to these carrier forces, and the U.S. Navy, in defense, is relying heavily on nuclear attack submarines. CNA analysts have helped to formulate and test procedures for using U.S. submarines in this role. The analysts have been instrumental in developing not only the techniques needed to evaluate the performance of the submarines, but the related command and control procedures, as well. The results have helped to improve coordinated operations by surface ships and submarines in defense of carrier task forces.

For a fleet to do its work, of course, it must also be able to protect itself against air threats. Defense against aircraft has traditionally been provided primarily by fighters flying from carriers. In modern air defense, airborne early warning aircraft detect enemy missile-launching aircraft and direct long-range fighters to intercept them before they can fire their missiles. CNA analysts have helped to develop and evaluate tactics that will enable fighter aircraft and early warning aircraft to operate farther from their carriers.

In wartime, the fleet may be called upon to protect convoys of merchant ships carrying men and material to our allies. But the advent of the nuclear submarine has intensified the problems of merchant ship defense. Recognizing the fundamental change, CNA made a study of novel concepts for protecting merchant ships in the future. One of the more promising ideas was a new form of convoy that might be as effective against nuclear submarines as the traditional convoy had been against conventional submarines. Testing the concept at sea was what was really needed to confirm the hope that it might be a breakthrough. CNA field representatives, augmented by analysts from CNA-Washington, helped plan the exercise, rode the ships, and evaluated the results. The exercise demonstrated that the new convoy design was not only workable, but even more effective than the theoretical calculations had predicted.

Of great importance to U.S. maritime power is knowing how the Soviets operate their naval forces and finding ways to exploit this knowledge. CNA field representatives have conducted on-scene analyses of Soviet operations and exercises. These analyses have helped to identify a variety of tactics and have supported efforts to gauge the effectiveness of those tactics. The analyses yield useful implications regarding the Soviets's command and control procedures, operational capabilites and, consequently, better information for the U.S. Navy's planners.

Strategic Studies

The coming of age of the Soviet navy as a fighting machine has long been generally known. That it has also become a tool of foreign policy, however, has been less well appreciated. To improve the quality of public and government debate about the Soviet navy's peacetime missions, CNA analysts presented results of their studies in *Soviet Naval Diplomacy*, which was published in 1979. This analysis of Soviet naval doctrine and operations shows that Moscow's commitment of its navy to a diplomacy of force was a comparatively recent decision, taken little more than a decade earlier, and that the decision did not rule out the possibility of involvement in limited war.

Given the risks that attend the heightening competition of the superpowers for influence on the high seas, the question arises: How has combat between them been avoided so far? Why, in other words, is coercive naval diplomacy alive and well today, despite the risks?

CNA research has shown that the answer lies in a set of unspoken "rules" or norms of behavior, observed by both superpowers, that allow them to play the "game" of naval diplomacy in the nuclear age. Under these "rules of the game," intervention to uphold a status quo that is accepted by both sides is permissible, as is action to confine such an intervention to purely defensive ends. Actions aimed at upsetting the status quo, however, are discouraged.

Although the "rules" reduce the danger of war, they do not eliminate it altogether. Nor is it likely that the Soviets will abandon naval diplomacy. As their behavior has shown, they view the risks as acceptable compared with the potential rewards.

One reward sought by the Soviets has been access to naval facilities abroad. The Soviets' search for access abroad has not always been successful, and their failures may hold lessons for the United States. Thus, when CNA investigated the prospects for U.S. access to naval facilities around the Indian Ocean, it was necessary to analyze the extensive experience of the Soviet Union with access to facilities in Indian Ocean states and in other nations of the Third World. U.S. experience, which consists mainly of dealings with U.S. allies or former colonies of allies, is of only limited value toward understanding what may lie ahead in the Indian Ocean.

Because of the unpredictable and rapidly changing circumstances typical of the Third World, access to a given country's facilities is not likely to last long. In Egypt and Somalia, for instance, Soviet access was relatively brief—in fact, lost before the Soviets could use costly installations they had built, notably the large airfield at Berbera, Somalia. To reduce the political and economic costs of tenuous relationships, the Soviets rely wherever possible on temporary and mobile facilities, such as communications vans, prefabricated housing facilities, floating dry docks, and yard oilers.

Whether or not the U.S. Navy has access to overseas facilities, it needs the freedom of the seas. In this last quarter of the 20th century, the international rules governing use of the sea and exploitation of its resources are under sharp attack. Many nations, rich and poor, have made unilateral claims to extended territorial seas, continental shelves, major fishing areas, and economic zones. Airspace over waters, transit through straits, and freedom to conduct scientific experiments have been threatened. The attempt to resolve these

problems took 15 years of intense negotiations, culminating in the draft treaty on the law of the sea, now being considered in the United Nations.

The draft treaty grew out of negotiations at the Third United Nations Law of the Sea Conference. Because a number of the issues on the agenda had important implications for the U.S. Navy's use of the seas, representatives of the Navy served on the U.S. delegation to the conference.

Before every major bargaining session, CNA prepared briefing books with analyses and forecasts on all major issues and on the tactical problems of advancing U.S. interests. Because the right of transit through straits is important to the Navy, CNA papers on the subject analyzed debates and votes, determining the support or opposition of various states to the U.S. proposals, the state of discipline of the caucusing groups identified as operating at the conference, and the tradeoffs that might be possible if the issue of straits were packaged with others.

Assessment of the Naval Balance

CNA's strategic studies have, of course, attempted to forecast the development of Soviet naval forces and their modes of employment in wartime. (See, for instance, "Reading the Soviets" in section II of this report.) Since the early 1960s, CNA has also conducted many studies of the relative strengths of the U.S. and Soviet navies.

Campaign analysis attempts to gauge the effectiveness of military forces in an extended series of battles. The aim of one CNA campaign analysis was to estimate the ability of U.S. and Allied naval forces to carry out their missions in a non-nuclear war between NATO and the Warsaw Pact in 1985. The study group investigated the possible objectives of both sides, the strategies they might use to pursue those objectives, and the likely outcome of the resulting naval campaign. All aspects of naval warfare—antisubmarine warfare, antiair warfare, surveillance, mining, and strikes ashore—were considered. The effects of geography and the contributions of the other U.S. services and the forces of our Allies, as well as the performance of individual weapon systems, were taken into account. The study produced a number of insights into the naval balance.

In some instances, new weapons and sensors appear to be compensating for the post-World War II decline in U.S. force levels. Efforts in antisubmarine warfare, for example, are paying off. New sensors appear to be improving the Navy's capability to counter Soviet submarines, particularly along the sea lanes of the North Atlantic.

In other cases, however, the decline in the U.S. fleet is painfully evident. Though combat on land might be centered in Europe, the war would be worldwide for the Navy. The U.S. has vital interests in the Pacific and Indian oceans, as well as the Atlantic, and the Navy would find it hard to meet its objectives in all areas at once. Even in the Atlantic, some missions would probably have to wait.

Of course, the Soviet navy would not have an easy task. Quite the opposite, in fact. New weapons and sensors are improving the offensive and defensive capabilities of U.S. Navy ships and aircraft. And geography would work largely to the advantage of the U.S. and its Allies. Moreover, the Navy could count on assistance from a large number of Allied ships, capable of protecting both military convoys and merchant shipping. Their presence would enable the U.S. fleet to concentrate on destroying Soviet forces.

Studies of Force Options

Assessments of force capabilities often help the Navy and Marine Corps to determine the types of new forces and weapon systems they should develop and procure. But there are usually difficult choices to be made. For example: Should a new ship or aircraft incorporate advanced technology or "state-of-the-art" technology? Are a few costly units more effective than a larger number of less-costly units? What is the tradeoff between the ships and aircraft that carry weapons and the sophistication of the weapons they carry?

CNA was formed just as the Secretary of Defense began to require the armed services to submit quantitative analyses of such issues, to demonstrate the soundness of their proposals for new forces and weapons. CNA has, therefore, conducted hundreds of studies and short-term analyses of alternative means of performing the warfare tasks of the Navy and Marine Corps. These may be grouped, for convenience, under four headings: strategic and tactical nuclear warfare, conventional warfare, mobility forces, and force-related systems.

Strategic and Tactical Nuclear Warfare

The Navy's fleet of ballistic missile submarines (SSBNs) has been a cornerstone of the U.S. strategy of assured destruction—that the Soviets would not start a nuclear war if they know that it would end in their own destruction. Assured destruction is still a part of the U.S. strategy, at least in the ultimate. Were the Soviets to strike in full force, U.S. casualties would be beyond all human experience, and retaliation would doubtless be swift.

But some planners have asked what the U.S. would do if the Soviets struck, not with their full force, but a portion, a portion aimed at destroying as much of our retaliatory forces—but as little of our population—as possible. With so many Americans still alive—and still at risk—would the President still destroy the Soviet Union in retaliation, knowing that scores of millions of Americans could soon die in a final Soviet strike?

Those who pose such questions say that the President must have some choices other than—as they put it—suicide or surrender. The options they propose have come to be known as the doctrine of "flexible response." The intent is to be able to respond to a less-than-all-out attack in a less-than-all-out way, to concentrate on military or economic targets rather than civilians, and to try to end the exchange before either side resorts to the ultimate in slaughter. Submarine-launched cruise missiles (SLCMs) have been proposed as a means of flexible response.

The strategic version of the Tomahawk SLCM, now being developed, grew out of several studies in the early 1970s, including one by CNA. The missile, with wings and tail folded, is small enough to be launched through the torpedo tubes of any U.S. submarine, submerged. Once in the air, it is powered by an efficient turbofan engine burning a special fuel that yields ranges well over 1,000 miles at very low altitudes. It is guided with extreme accuracy by a system that finds its way by recognizing the topography of the land below. Though subsonic, the missile's small size and low altitude should make it a tough target. CNA has studied the use of the SLCM in flexible-response missions.

The CNA study concentrated on the economics of the SLCM in comparison with bombers, land- and sea-based ballistic missiles, and even tactical aircraft in such missions. The costs of such missions, and the reliability with which they can be carried out, depend in a major way on the effectiveness of future air defense systems, an area of great uncertainty. Nonetheless, the analysis makes a strong case for the SLCM.

Ballistic and cruise missiles are intended for use against strategic targets on land. The Navy also has a stock of so-called tactical nuclear weapons, to be used by aircraft against ships or shore bases. Others are used in antisubmarine depth bombs, or torpedoes, or as the warheads for antiaircraft missiles to protect the fleet. Most of the current stock of tactical nuclear weapons were manufactured in the early 1960s, with 1950s technology.

CNA undertook a comprehensive study of all current types of Navy tactical nuclear weapons in comparison with all conventional weapons available for similar tasks. Some of the older nuclear weapons proved less effective than their modern conventional counterparts for some missions. The Navy, at least partly as a result of this work, began to change its inventory of tactical nuclear weapons. The study also had an unexpected side benefit in highlighting some possible weaknesses in specific conventional weapons, and work is underway to improve them.

Conventional Warfare

A major issue of the early 1960s was the relative cost and effectiveness of land-based and sea-based tactical aircraft. At one time, Secretary of Defense McNamara was prepared to reduce the number of aircraft carriers and increase the number of Air Force air wings. CNA's first study of the tradeoffs between Navy and Air Force tactical air had much to do with Mr. McNamara's change of mind.

In the 1970s, attention turned to these questions about the future of sea-based aviation:

- Should the U.S. have a few large carriers or a larger number of smaller ones?

- Should the aircraft that operate from those ships be like those in today's fleet, or should they be replaced by fixed-wing aircraft that can take off and land vertically?

A series of three CNA studies looked at the costs and benefits of alternative types of aircraft and carriers, 20-30 years ahead. Alternative equal-cost forces were compared for performance in various situations. The findings concerning aircraft design are inconclusive; aircraft that can take off and land vertically are more effective in some situations, conventional aircraft in others. Findings about carriers, however, are more clear-cut: Large carriers were found to be more effective, dollar for dollar, than smaller carriers.

It has long been thought that, as in World War II, an important wartime mission of the Navy would be to escort convoys of merchant ships across the Atlantic. As noted earlier, CNA's research into the convoying problem led to a new, more effective design for convoys. CNA continued its work on convoys, concentrating on the potential and the problems of new technology—the potential offered by our own new technology, the problems posed by the enemy's.

Two technological developments on the enemy's side make it harder to defend convoys: quieter submarines and submarines armed with guided missiles. With these technological developments (and more), it was clear that old ideas about the best ways to defend convoys, and about the forces to buy for that job, were badly in need of updating.

CNA's study considered some 15 alternative forces for defending a convoy. These comprised, in various mixes, destroyers and frigates, land-based patrol aircraft, small helicopter carriers, and submarines in direct support of the convoy defenses. The study also considered various threats, some emphasizing submarines armed with cruise missiles, others concentrating on new and especially quiet nuclear submarines. Still others emphasized diesel submarines (which the Soviets are still building and which, when running on battery power, are quieter than even the quietest nuclear boats). Finally, the study considered operations against single submarines and wolfpacks, in shallow water and deep, and in good acoustic conditions and bad.

From all this work, CNA was able to map out the changes in the effectiveness of convoy defense that follow improvements in the

defense forces, from the most austere to the most expensive, and to specify the best combination of forces to buy at any level of expenditure.

Mobility Forces

A CNA study in the mid-1960s helped the Navy choose the LHA as its main amphibious assault ship for the future. The LHA, unlike earlier amphibious ships, carries all three types of vehicles used to move assault forces from ship to shore: helicopters, landing craft, and tracked amphibians. Later CNA studies have confirmed the value of ships that can carry all three types of ship-to-shore vehicles.

Several studies have evaluated alternative designs for the ship-to-shore vehicles. Perhaps the most radical of those considered has been the air-cushioned landing craft.

The landing craft that now carry Marines and their combat equipment to shore have not changed much from the ones designed and built during World War II. Because of their low speed they must be launched close to shore. As a result, the amphibious task force is vulnerable to enemy artillery and missiles. In addition, today's craft must unload cargo on the beach, tending to create a logistics bottleneck and increasing the exposure of Marines and their equipment to enemy fire. Beach gradients, surf and tide conditions, and such obstacles as sand bars and reefs limit the time and place of landings, thus allowing the enemy to concentrate his defenses on the beaches where landings are possible.

To overcome these disadvantages, the Navy started work on the experimental air-cushion landing craft, which rides on a bubble of compressed air without touching the water. Because air-cushion craft travel at 50-60 knots, the amphibious task forces can stand off farther from shore and be less vulnerable to fire. Air-cushion craft can also unload their cargoes inland, avoiding the logistics bottleneck. Moreover, they can operate in sea states, surf, or beach conditions that today's landing craft would find impassable. In short, these craft open more beaches to attack, more of the time. As might be expected, the new landing craft cost more, about four times as much to buy and operate as those they would replace.

CNA's analysis showed that the advantages of the air-cushion craft—its higher speed and its ability to land at a wider variety of sites, under a greater variety of conditions—more than compensate for its higher cost, if the Navy replaces its older amphibious ships with ships that can carry the air-cushion craft.

To realize the strategic and tactical advantages inherent in its forces, the Navy commits a portion of its budget to underway replenishment (unrep) ships and logistical aircraft. An aircraft carrier depends on carrier-onboard-delivery (COD) aircraft for critically needed personnel and spare parts.

Today's COD aircraft are old, and the Navy has been trying to buy new ones since 1972. But Congress has turned down these requests, in part because of uncertainty about what these aircraft would be expected to carry. The Navy asked CNA to look into the COD, with special emphasis on determining its cargo.

By laying out situations in which battle groups are likely to be involved, selecting for consideration the aircraft that could be used in the COD mission, and estimating the demand for personnel and parts, the study group found that each battle group would need about 1,300 cubic feet and 15,000 pounds of COD deliveries a day in wartime.

CNA's analysis showed that the improved C-2 aircraft, derived from the E-2C, was the least expensive aircraft that could carry out the COD mission. CNA analysts worked with the Navy to find out how many improved C-2s should be bought and how these new aircraft would fit in with the few COD aircraft now in the inventory.

Force-Related Systems

The solution to a problem in naval warfare is not always to buy new ships or aircraft. Sometimes, existing forces can be made more effective by tactical improvements devised through operations analysis. Or ancillary systems may be adopted, to improve the effectiveness of forces already in hand.

Most naval combat units carry equipment to find and track nearby enemy forces. But these combat units also need more information

than their own sensors can provide. They—and, particularly, the higher echelons of command—need to know where enemy forces are, in the vast reaches of the ocean. To the extent that U.S. forces have this information, their effectiveness can be multiplied.

There is little new in this concept. What is new, though, is the wealth of opportunity for ocean surveillance that modern technology now offers. In addition to modern versions of traditional radio direction-finding equipment, technology now makes possible extremely sensitive long-range sonar equipment, radar that is no longer limited by the horizon, infrared devices that detect targets by the heat they emit, and other such devices. Moreover, some of these sensors can now be placed on satellites, in addition to land installations, ships, and aircraft.

The other side of the coin, of course, is that these new systems, together with the communications it takes to tie them together, tend to be costly. Before they are bought, some questions must be answered:

- How much more effectiveness is bought by improvements in surveillance?
- For any given amount of money, what is the best mix of surveillance systems?
- What can an enemy do to defeat a system?
- How well are these systems likely to operate after the enemy introduces his own technological improvements?

To help answer these questions, CNA conducted the first comprehensive study of ocean surveillance systems. That study, and several since, have helped the Navy determine the types of systems it should develop and buy.

The armed services have also sought ways to exploit laser technology. Laser designators have been developed for use in pinpointing attacks on land targets. A forward observer on the ground "designates" a target by training an invisible laser beam on it. Sensors in the artillery shell or bomb being aimed at the target pick up the reflected laser beam and guide the projectile to it.

For this purpose, the Army developed two designators: a light, short-range one and a heavier one of longer range. The Marine Corps has been developing a designator of intermediate range, the Modular Universal Laser Equipment (MULE). The MULE can be operated while hand-held.

The Department of Defense directed the Army and Marine Corps to analyze the three systems, with respect to both effectiveness and cost. CNA did the analysis for the Marine Corps. The analysis showed that if only the Marine Corps were to buy the MULE, the system would be slightly less cost-effective than a variant of the long-range system. The long-range unit, however, has serious disadvantages for the Marine Corps: the need for an extra man to make it man-portable, and its bulk, which prevents its use where a smaller, hand-held device is needed. Consequently, CNA recommended that the Marine Corps continue to develop the MULE and buy it.

Resource Management Studies

There is, of course, more to military effectiveness than selecting forces and deciding how to use them. Forces must be manned; their readiness must be assured through provisioning, maintenance, and operations. Moreover, policies for force selection, manning, and readiness must be executed in the face of limited budgets.

Manpower Selection and Retention

The challenge of manning the military did not arrive suddenly with the all-volunteer force (AVF) in 1973. Though the Navy and Marine Corps acquired first-term enlisted personnel and a few officers (doctors, mostly) through conscription—or the threat of it—the tasks of selecting, assigning, and keeping skilled manpower in the services are difficult, with or without a draft.

Whether potential recruits respond to the compensation offered under the AVF or to a draft notice, they must meet mental and physical standards set by the armed services. Before prospective recruits are accepted, their mental aptitude is measured by means of the Armed Services Vocational Aptitude Battery (ASVAB).

CNA has conducted two analyses of the forms of the ASVAB that went into use in 1976. The first showed that the ASVAB was incorrectly calibrated, that more low-aptitude recruits were being enlisted than the Department of Defense (DoD) had reported. At the request of DoD, CNA conducted a second analysis, based on data collected specifically for test calibration. The results showed that the test calibration was even less accurate than the first analysis had found. The ASVAB was greatly overstating the ability of recruits. DoD sponsored two independent studies of calibration of the ASVAB. Both confirmed CNA's findings. DoD therefore reported to Congress that official statistics about the mental aptitudes of recruits had been wrong since 1976 and that approximately six times as many low-aptitude recruits had been accepted as had been thought.

CNA also worked with a joint service group to design, construct, and calibrate new forms of the ASVAB. These went into use in 1980.

The primary criterion for accepting physically fit men in the Marine Corps had been mental aptitude. CNA found, however, that completion of high school is a much better indicator of future success in the Corps. A high school graduate, in fact, is about twice as likely as a non-graduate to become a sergeant or to be eligible and recommended for reenlistment by the end of his four-year tour. By the same criteria, graduates in the lowest mental group accepted by the Marines were as successful as non-graduates in the highest mental group. Non-graduates were about twice as likely as graduates to desert or be discharged before the end of their enlistment. After these studies, the Marines changed their policy. Since FY 1977, 75 percent of enlistees must be high school graduates, in contrast to 50 percent before.

CNA has also developed recruit-screening methods for the Navy. Based on observation of the entire cohort of recruits entering the Navy in 1973, CNA estimated the probability that men with certain background characteristics would survive the first year, the second year, or later years in their first enlistment. With this process, not only could recruiting efforts be tailored to enlist those most likely to succeed (saving time, effort, and money) but the number of survivors could also be estimated for various points during the first term (enabling the Navy to plan better). Furthermore, the CNA analysis showed that high school graduates, even of below-average mentality,

did better than non-graduates of above-average mentality. This finding opened up an important new supply of recruits.

The CNA screening process was formally adopted by the Navy in 1976. Since then, CNA has developed faster and less expensive methods for developing screening profiles. The method employs a special biostatistical technique called the Cox regression model. It has two advantages. First, it yields curves showing the survival chances of recruits, from entry to the end of their first enlistment, instead of point estimates of survival at discrete intervals. The second advantage is that the Cox regression model can be applied to cross-sectional data, making it unnecessary to track a cohort of enlistees for several years.

In addition to research into recruiting and screening of recruits, CNA has conducted a series of analyses relating compensation to retention. The loss of enlisted careerists has probably been the Navy's most important personnel problem. Many past studies of the effects of compensation on retention have significant limitations. First, most of them have relied on data from the draft era, but the relation between pay and retention may have changed with the end of the draft. Second, only first-term reenlistments have been considered; the effects of pay raises on later reenlistment decisions can only be inferred from these studies. Third, most of the earlier studies have derived single estimates of the effects of pay changes by grouping data on bonuses and reenlistment rates for several military occupations; yet, occupational groups may differ systematically in their response to pay changes. Finally, earlier studies have estimated the immediate effects of first-term reenlistment bonuses, but not their effects on second-term reenlistments.

CNA's study of the problem estimated the effects of pay raises on both first- and second-term reenlistment decisions. The analysis yielded estimates of the effects of raises on retention, according to the proportion of time an enlisted person spends in sea duty, which depends on the occupational group to which the person is assigned. The effects of first-term bonuses on second-term reenlistments were also determined. The analysis showed that the larger the first-term reenlistment bonus, the lower the second-term reenlistment rate. This means that individuals who are induced to stay because of higher first-term bonuses are in fact less career-committed and therefore less

likely to reenlist after a second term. In current force planning, retention rates at various terms of service are viewed as independent of one another; the future effects of changes to first- or second-term bonuses are not considered. The results of the CNA study suggest they should be.

The amount of retirement pay and the time it may be taken also affect retention. CNA has analyzed a proposed two-tier retirement plan. The plan would eliminate 20-year retirement. Instead, it would provide an old-age annuity and a lump-sum cash payment to anyone who left after 10 years. Benefits would be increased significantly for anyone who left with 10-20 years of service, but benefits for anyone who served for more than 20 years would be reduced, unless he served a full 30 years.

CNA found that a two-tier plan would lead to lower retention of personnel with 10-20 years of service, but higher retention before 10 years and after 20 years. On the balance, it appears that a two-tier retirement plan would allow the services to obtain a more productive mix of enlisted manpower, without increasing the total compensation paid to active and retired personnel. A two-tier plan would also lower yearly accession requirements, an important consideration in an era when the manpower supply is declining.

Planning and Execution

In the spring of 1969, the Secretary of Defense revised the Planning, Programming and Budgeting System. A key feature of the new system, which survives in much the same form, is the Program Objectives Memorandum (POM). Every year, each service submits a POM detailing a five-year program within the budget constraints set by the Secretary of Defense.

CNA helped the Navy adjust to the new system by developing the Navy Resource Model. The model allows the Navy to quickly construct and compare alternative programs that satisfy the Secretary of Defense's fiscal guidance. Using the model, the study group helped the Navy put together its first POM.

After review and revision, the first year of the five-year program covered by a POM becomes the Navy portion of the Defense budget

that is submitted to Congress every January. Once Congress has authorized programs and appropriated funds for them, the Navy is responsible for their execution, at the cost approved by Congress.

Because of the complexity of Naval ships and the length of time they take to build, their costs have proved especially difficult to predict and control. In World War II, it cost $10 million to build a destroyer. Nowadays, the cost is nearer $300 million. Because of limitations on the Navy's shipbuilding budget, such huge increases make it hard to have enough ships in the fleet.

A sudden increase in orders for commercial ships would further increase the cost of Naval shipbuilding programs. Such an increase was threatened in 1977, when Congress considered legislation to raise from five to 30 percent the fraction of oil imports arriving in U.S.-built tankers. Congress had passed a similar bill several years before, but the President had vetoed it, partly in response to a request by the Navy. When the new bill was proposed, the Navy decided to reevaluate its position. There were reports that orders for new commercial ships had fallen off, that shipyards might therefore be able to handle a large program of tanker construction.

CNA's analysis showed that attempts to meet the legislative target of 30 percent would certainly lead to cost increases and delays in construction of warships. An additional 12 million tons of tanker capacity would be required, more than the total U.S. tonnage at the time. For this new capacity to be in place within three years, shipowners would have only a few months to decide on the mix of sizes they wanted and then carry out the detailed design work. Shipyards would have to expand total employment at an annual buildup rate of more than 40 percent. By comparison, the highest buildup rate in the past 15 years was about 10 percent.

The Navy concurred in the study's main finding: that the proposed goals would threaten the Navy's construction program. It supported a much less ambitious goal that was clearly within the range of possibility found by the study. The original cargo preference bill was later defeated.

Non-Defense Research

Most of CNA's non-defense research has been in industry studies and labor economics.

Industry studies, involving development and estimation of econometric models of supply and demand, have aimed at measuring how changes in government policies—either specific regulations or levels of spending—change output, prices, wages, employment, and in some cases, foreign trade, in the affected industries. In all cases, the studies have paid particular attention of the process of adjustment to change. Examples of this type of work are a study of how expenditures mandated by the Environmental Protection Agency to meet environmental qual' y standards will affect the construction industry, a study of how removing restrictions on imports of steel would affect the steel industry, and a study of how labor adjusts to technical change in steel, autos, aluminum, and iron ore mining.

Studies in labor economics have also examined adjustment problems. A series of econometric studies of the Unemployment Insurance (UI) System have examined variations in state UI laws and have measured the effects of these variations on the duration of unemployment, the productivity of job search by the unemployed, and the hiring, overtime, and layoff decisions of employers. Other studies—in several cases, integrated with industry studies—have determined how job losses resulting from a permanent reduction in demand have affected the long-term employment and earning prospects of displaced workers. Most of these studies in labor economics have made use of longitudinal earnings and employment histories of individual workers, drawn from administrative records of the Social Security System or the UI system.

In addition to these topics, CNA has measured the cost of gathering government statistics, has developed a method for measuring the retail price of heroin (the procedure is now being used by the Drug Enforcement Administration), and has studied such varied matters as problems of health, education, urban crime, library planning, and national policy toward ocean resource development.

TODAY AND TOMORROW

Section II of this report details some of CNA's accomplishments in 1981—its twentieth year. Those accomplishments owe much to the general stability in CNA's funding and the continuity of its research. As a result of this stability and continuity, CNA has been able to attract and keep analysts of high quality, and dig deeply into problems of national importance.

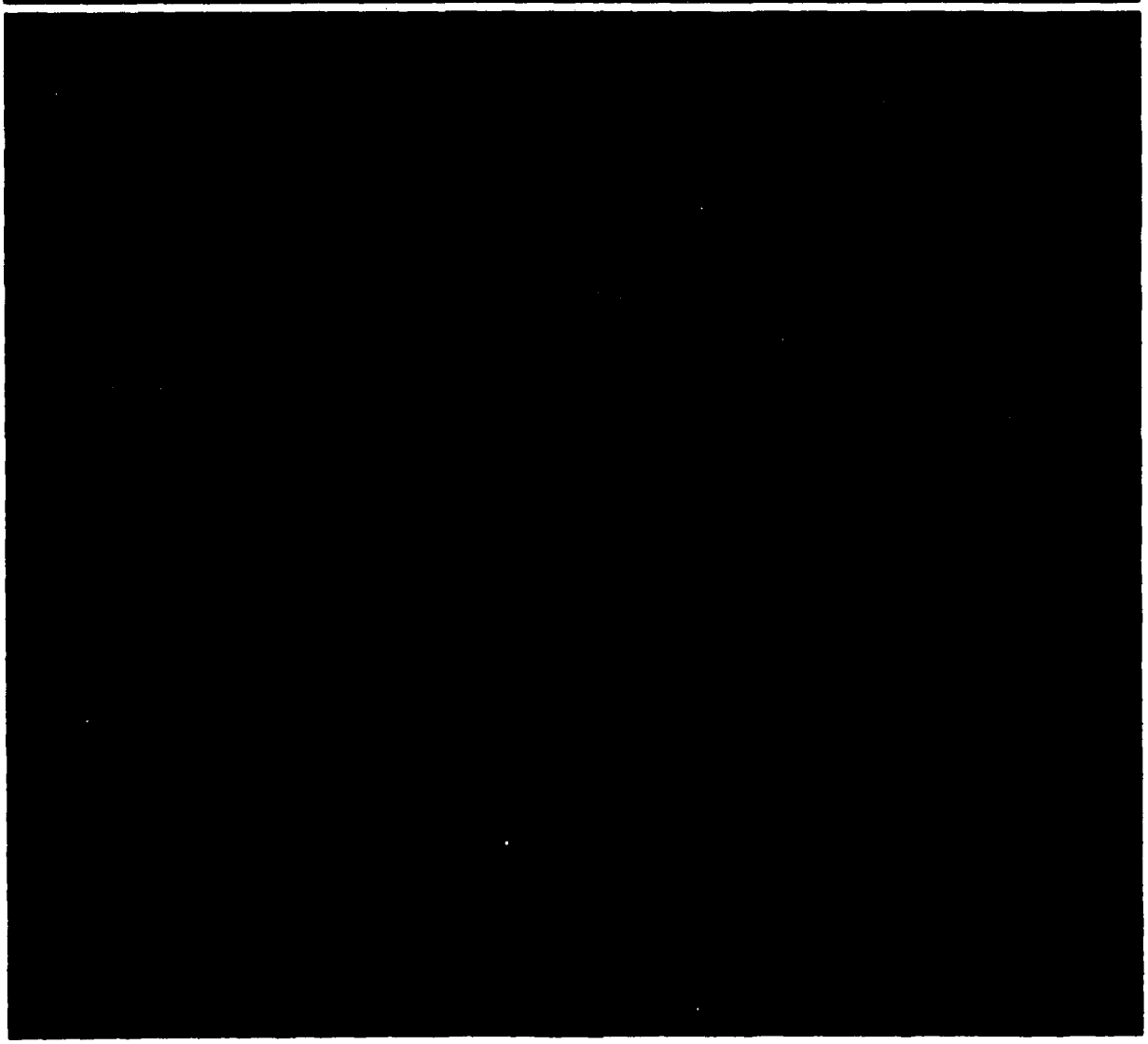
But there are important classes of problems to which CNA could give more attention than it has: the exploitation of new technology, long-range planning for the Navy, the course and conduct of naval warfare in the future, and Navy management procedures. Research in these areas is necessarily more speculative than traditional operations analyses and cost-effectiveness studies. Alternatives are not always obvious or easily compared; mathematical or statistical models are seldom applicable; experience may often have to be substituted for hard data. More than ever, the criterion for success will have to be whether an analysis has identified the essential elements of a problem, not whether it has come up with a clear-cut solution.

Accordingly, as discussed in section III, CNA's management has reshaped a sizable portion of the organization, not only to focus more attention on relatively neglected issues, but also to give institutional protection to what will be—for a while at least—exploratory research.

The success of the exploration will rest on the willingness of CNA's management to support some risky analyses, and the willingness of CNA's staff to take more analytical risks than they have, perhaps, been used to.

Future reports will tell the results of this venture.

1981
RESULTS



The examples in this section represent only about a fourth of CNA's research during FY 1981. Classified details have, of course, been excluded. Nevertheless, these brief descriptions give something of the flavor of CNA research in the past year. The research outlined here is reported in detail in CNA publications. The classified publications are available to qualified recipients.

These are the subjects covered:

Current Forces and Operations
- The Naval Balance in Key Regions
- How Capable Are the Navy's Antisubmarine Forces?
- New Tactics for Fleet Air Defense
- Aiming at Targets Over the Horizon
- "Graduation" for Aircraft Carriers

Strategic Aspects of Force Planning
- Reading the Soviets
- Can the Soviets Interdict the Sea Lanes—and How?
- China's Quest for Sea Power
- Will the Navy Run Out of Fuel?

Future Forces and Systems
- Shaping Tomorrow's Amphibious Forces
- How to Deploy Marines
- Control Systems for Marine Forces
- Space-Based Navigation for the Navy
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CURRENT FORCES AND OPERATIONS

The Naval Balance in Key Regions

In 1981, CNA completed two studies of the balance of U.S. and Soviet naval forces in strategically important regions of the world. One study hypothesized a U.S.-Soviet conflict in the Indian Ocean; the other, the possible outcome if there were a battle in the Mediterranean.

In the wake of the Iranian revolution and the Soviet invasion of Afghanistan, the United States deployed additional Naval forces to the Indian Ocean. As symbols of national resolve, the forces are intended to deter acts hostile to U.S. interests in the Middle East and Southwest Asia—in particular, attempts to cut the oil lifeline from the Persian Gulf to the U.S. and its allies. The effectiveness of a deterrent force depends, of course, on its fighting strength.

The Director of Naval Warfare asked CNA to evaluate the Navy's ability to conduct combat operations in the Indian Ocean, if Soviet opposition were encountered. CNA examined several aspects of U.S. Naval operations, with equal emphasis on offensive strikes, subsequent combat, and logistic sustainability.

The possible offensive operations that were analyzed consisted of air strikes, mining, antisubmarine warfare, and amphibious landings. Analyses of subsequent combat dealt with threats from submarines, long-range bombers, and mines. With regard to logistic sustainability, the study considered two issues: whether there are enough cargo ships and tankers available to support forces in the Indian Ocean and whether that logistic train can be organized in time to support those forces.

The analysts identified specific strengths and weaknesses of the U.S. naval posture in the Indian Ocean and recommended early actions to strengthen that posture.

CNA's study of a Mediterranean campaign addressed concerns of the Commander in Chief, U.S. Naval Forces Europe (CinCUSNavEur), about the survivability of his forces when they are in the central and eastern Mediterranean, close to Soviet warships and within striking

range of Soviet land-based aircraft. The analysts calculated the likely outcomes of engagements that followed a surprise attack on the Sixth Fleet by Soviet naval forces, under a variety of circumstances.

Concepts of U.S. and Soviet operations, models of combat between the opposing forces, and inputs to the models were drawn to a large extent from an earlier CNA study, Sea War 85 (described in section I of this report). As with Sea War 85, the study of a 1981 Mediterranean campaign considered the possible objectives of both sides, the strategies they might use to pursue those objectives, and the likely outcome of the resulting campaign.

In addition, the study examined the effectiveness of some of the new rules of engagement (ROE) that had been proposed by an earlier CNA study. The study of the Mediterranean campaign showed how the ROE—among other measures—could reduce the vulnerability of the Sixth Fleet to surprise attack. CinCUSNavEur drew heavily on the study in drafting a concept of operations for forces in the Mediterranean.

How Capable Are the Navy's Antisubmarine Forces?

Some of CNA's 40 field representatives are assigned to submarine commands and some to antisubmarine warfare (ASW) aircraft commands. One important activity of these analysts is reconstruction of operations and exercises by combining reports from participating units. The results of a reconstruction often differ from the impressions carried by participants: Some reported detections of submarines prove to be false contacts; some attacks on and by submarines turn out to be inaccurate. Reconstructions thus afford a measure of the Navy's actual ASW capabilities and suggest means of improving them.

The effectiveness of submarines in ASW is evaluated periodically in exercises during which torpedo attacks are simulated. Tracks of the simulated torpedo firings are compared with target tracks to determine whether the torpedoes would have hit or missed. These evaluations do not usually consider evasive actions by the targets. To estimate the effects of evasion, a CNA analyst has developed a simulation model of the movements of a torpedo and a target, from the time of torpedo launch. The model can be used to assess what

would have happened if the target had maneuvered after detecting the attack. The resulting estimates of effectiveness give a better picture of the ability of U.S. submarines to hit real targets.

The model has also been used in the evaluation of new tactics and weapons. It was used, for example, to simulate the performance of an improved torpedo against evading targets. In addition to assessing overall performance, the model identified changes in performance attributable to changes in individual characteristics of the torpedo.

CNA analysts have also been helping the Navy to evaluate the tactical towed-array sonar (TACTAS), a string of hydrophones encased in a plastic tube that is towed behind a ship to listen for submarines. Two versions of TACTAS, the SQR-18A and SQR-19, are scheduled for installation in many cruisers, destroyers, and frigates. From 1976 to 1980, developmental models of the SQR-18 were mounted on two frigates. To estimate the ability of ships equipped with TACTAS to detect, locate, and track submarines, CNA analyzed data from several exercises and operations involving these frigates. The analysts also assessed the system's performance in various operating areas and types of exercises. Changes in performance between the Atlantic and the Mediterranean were identified, as were changes associated with the numbers and types of ships involved.

New Tactics for Fleet Air Defense

Soviet Naval Aviation bombers armed with long-range cruise missiles pose a major threat to carrier battle groups. Some of these missiles can be launched at more than 150 miles from a battle group. The small size and high speed of the missiles make them hard to counter. Moreover, the Soviets can attack simultaneously from different directions with many aircraft. They may also be able to disrupt radar and communications.

The Pacific Fleet has devised tactics—called Vector Logic—to meet this threat. One element is stationing of fighters far enough from the battle group to engage Soviet bombers before they launch their cruise missiles. Preplanned responses have also been devised to mitigate the loss of radar surveillance or communications. CNA field representatives, assisted by analysts from CNA-Washington, have helped to design tactical dispositions and preplanned responses.

Before the tactics are adopted by the Navy they must be refined and evaluated. CNA has therefore been involved in setting up test exercises—some involving an entire airwing and battle group. Drawing on the results of the exercises and on models of aerial combat, CNA analysts have determined conditions under which the tactics may be used and have estimated their effectiveness.

Aiming at Targets Over the Horizon

The effectiveness of the Navy's new long-range antiship weapons—Harpoon and Tomahawk—will depend, in part, on over-the-horizon (OTH) targeting. When an attacking unit cannot "see" a target, the position of the target must usually be determined from reports by other units—ships, submarines, aircraft, helicopters—and by land-based radio direction-finders.

The Navy is evaluating several models that convert these reports into a continuous estimate of a target's position. Because no target can be located precisely, the models also estimate the area of uncertainty around an estimated position. The size of the area varies with the accuracy of location reports and increases as the last location report becomes older. Because a missile's search area is limited, the size of the area of uncertainty around a target determines whether the target's position is known well enough for attack.

To help the Navy in its evaluation, a CNA analyst collected target-position reports and data about actual target positions from recent exercises. The information was used in two OTH targeting models to produce estimates of the target positions and uncertainty areas. Comparison of the estimated and actual positions revealed problems in both models.

"Graduation" for Aircraft Carriers

U.S. aircraft carriers deploy overseas for at least six months at a time. Because every deployed carrier and its airwing must be combat-ready, every preparation for deployment—called a "workup"—is carefully planned and painstakingly executed. Carrier group commanders develop and carry out detailed workup plans.

At-sea workups begin with refresher training for ship, flight deck, and airwing personnel. Refresher training is followed by type training

(TYT), which is usually divided into three periods, each about two weeks long. The initial events of TYT emphasize the performance of individual tasks. As TYT progresses, the events build in difficulty and sophistication to include coordinated operations by all units of a carrier group and exercise of their various warfare capabilities. Based on his assessment of progress, the carrier group commander may choose to modify the training plan.

The final event of TYT is a three-day "mini-war"—the Opertional Readiness Evaluation (ORE)—which the carrier group commander plans and coordinates. In the ORE, some ships, submarines, and aircraft of the carrier group simulate attacks on the carrier. The performance of the carrier and its airwing is then graded.

Since 1979, CNA has been helping the Atlantic Fleet's carrier group commanders in their assessment of carrier and airwing performance—first in antiair warfare, and later in antisurface and antisubmarine warfare. During the OREs, teams of CNA analysts collect and evaluate data from both sides of the "mini-war," reconstruct and analyze engagements, and present their evaluations to the carrier group commander and his staff.

STRATEGIC ASPECTS OF FORCE PLANNING

Reading the Soviets

On several occasions in the 1970s, developments in Soviet weaponry caught the West by surprise. Part of the reason is the almost total reliance on technical intelligence and the relative neglect of literary intelligence drawn from Soviet writings. This neglect arises largely from the lack of an agreed-upon method of interpreting Soviet writings and a lack of faith in literary intelligence on the part of decision-makers, who have no basis for choosing between competing interpretations and are unaware of the value of the conclusions that can be drawn if Soviet writings are carefully analyzed.

CNA's analysts of Soviet military affairs have found that the open Soviet literature is not only *a* source for determining intentions, but in some cases the best and even the *only* source. In any event, Soviet writings seem to be the earliest source; Soviet doctrinal statements usually precede the appearance of capabilities that are afforded by

new weapons. Sometimes it is late in the Soviets' five-year planning period before new capabilities are deployed; it is sometimes even rather late before convincing evidence of weapons development accumulates. But it appears that the Soviets begin to discuss new options on the eve of a planning period, though in a form that demands great interpretative skill to understand.

To demonstrate the value of literary intelligence, delineate their methods of analysis, and encourage the formation of a common analytical approach, CNA's analysts have been conducting formal studies and holding seminars with interested analysts and consumers of intelligence. The studies and seminars have dealt with a number of problems in analyzing the Soviet press: the question of the authoritativeness and reliability of Soviet statements; the Soviets' use of historical and current foreign surrogates for their own views; definitional problems; the Soviets' practice of expressing their views by standard formulas and of indicating shifts in view by slightly changing the wording of formulas; their use of elliptical logic and expression, and non-sequential and implicit logic; and finally a common denominator of most of these problems—their implicative technique, where they imply and the reader must infer.

The work done to date leads CNA's analysts to conclude that there is good agreement between emerging Soviet capabilities and the doctrinal statements that accompany and even lead them. Moreover, there seems to be a class of Soviet statements that signal long-range intentions. Systematic analysis of literary intelligence and the creation of confidence in its results should not only reduce uncertainty about Soviet intentions but help to avoid surprises.

Can the Soviets Interdict the Sea Lanes—And How?

If war should break out between NATO and the Warsaw Pact, the United States would have to send massive amounts of supplies to Allied armies fighting in Europe. Most of these supplies would have to go by sea, and it would be the Navy's job to get them across.

Many attempts have been made to determine the forces and strategies needed to protect the sea lines of communication (SLOC). In 1981, CNA completed a study that took a different approach, examining the issue from the Soviet point of view. The goal was not to predict

the outcome of an anti-SLOC campaign, but rather to identify the factors that might govern the outcome—particularly those that the Soviets could control or influence.

The study team considered three potential Soviet threats to the SLOC: Backfire bombers, nuclear-powered submarines, and diesel submarines. It looked at what might happen if these bombers and submarines were used against ships at sea, and it examined the alternative possibility that they might be sent to bomb or mine the European ports where supply ships would have to unload.

The Soviets might have to pay a high price for attacking the SLOC—perhaps too high for the results expected—but the study identified many ways in which they could raise their chances of success and inflict substantial damage on shipping in the SLOC.

The results of the analysis have been used by the intelligence community in its assessment of the vulnerability of the SLOC.

China's Quest for Sea Power

A Naval officer assigned to CNA has written *Eighth Voyage of the Dragon: A History of China's Quest for Sea Power.* The book will be published by the U.S. Naval Institute Press in 1982. It deals with Chinese seapower in three periods: Imperial (10th century A.D. to 1911), Republican (1911-1949), and Communist (since 1949).

The history of the Imperial period introduces a fundamental constant of Chinese history—the conflict between continentalism and maritimism. The conflict evolved in the 10th century A.D., when China's old continentalist society spread down the rivers to the sea, conquering the many disparate tribes that populated the southeastern coasts. Over the next thousand years, four dynasties—the Song (906-1279), the Yuan or Mongol (1279-1368), the Ming (1368-1644), and the Qing or Manchu (1644-1911)—tried to meet the challenges posed by sea travel, ocean trade, and foreign ideas.

Emperors and officials who saw the advantages of maritime expansion were often thwarted by entrenched land-oriented bureaucracies. The early Ming naval expeditions to Africa proved that Chinese shipbuilding techniques and navigational abilities were unmatched by

those of any other nation of the time. The seventh and last expedition ended in 1433.

The "Eighth Voyage" is the post-Ming quest to restore Chinese greatness on the sea. Among the shortcomings that prevented Imperial China from continuing that greatness were these:

- Lack of strong, enlightened leadership
- Lack of consensus and coherent planning
- Overdependence on foreign advisers
- Inability to train an integrated, specialized technical force
- Failure to grasp new strategies, tactics, and administrative techniques
- Development of naval cliques.

The history of the Republican period emphasizes the Chinese navy's role in foreign relations, specifically with Great Britain, the United States, Russia, and Japan. The key point—the navy's attractiveness to foreign businesses and politicians—is still valid today. China's navy offered the possibility of high-stakes contracts, and it was a force whose allegience and influence might be useful to whichever foreign power could win its support.

The history of the Communist period relates the development of the Communist navy to the events of earlier epochs. It also traces the growth of the modern Communist navy to its present position as the world's third largest in numbers of ships. To a striking degree, even the navy's distant history has a strong influence on its present. The effect can be seen especially in the navy's organizational structure and its perspective on strategy and tactics.

Finally, the book shows how the West, particularly the United States, now views China in a larger strategy—as a valued friend whose assistance is needed to contain Soviet expansion in Asia. In view of the dismal record of China's past attempts to modernize its navy, future Western attempts to help that navy must be precisely calculated, understood, and coordinated among all the nations involved. The key factor in such calculations is a thorough understanding of the history of China and the sea.

Will the Navy Run Out of Fuel?

Last year the Chief of Naval Operations expressed concern about the availability of fuel to power the fleet's ships and aircraft in 20 or 30 years. He directed his Long-Range Planning Group to look into the question and to determine the implications of the findings for the future Navy. The Planning Group asked CNA to help.

The CNA analysts first examined the changes in the oil market since the 1973 embargo and the effects on the Navy. Next, they evaluated several conflicting forecasts of worldwide oil supply and demand, looked at the effects of past disruptions in the oil supply, and assessed the likelihood of future interruptions and the potential consequences for the Navy. Finally, the analysts identified and evaluated measures the Navy can take to reduce its consumption of petroleum fuels and increase its access to available supplies.

The study found that the Navy will be able to get adequate supplies of petroleum products through the 20th century, either from conventional oil or from petroleum substitutes derived from heavy oil, coal, or shale. In the event of an interruption—even a total stop—in imports, the nation's domestic production and planned reserves could meet the requirements of the military, through existing mechanisms by which the government can acquire fuel for military use when supplies are short.

Although the Navy is expected to have enough fuel through the year 2000, the fuel will cost more and be of lower quality. Greater use of high-sulphur crudes and synthetics means higher processing cost, lower-quality fuel, and, therefore, a need for more maintenance of engines.

Soaring oil prices in the 1970s led to reductions in the size and readiness of the Navy; higher costs in the future can erode its capabilities even more. The Navy may have to make greater use of nuclear, diesel, and steam propulsion in ships, and relax fuel specifications to allow use of fuels common in the civil sector.

FUTURE FORCES AND SYSTEMS

Shaping Tomorrow's Amphibious Forces

The amphibious forces of the Navy and Marine Corps can inject

measured amounts of power into conflicts at the right places and right times. Successful amphibious operations depend largely on having a mix of ships, landing craft, assault vehicles, and helicopters that will get the Marines ashore quickly, ready to fight.

Over the next two decades, many amphibious ships and ship-to-shore vehicles will become obsolete. For example, all of today's landing craft should be retired in 10 years, and all but six amphibious ships by the turn of the century. The possibility of new designs for ship-to-shore vehicles and the modernization programs now being considered by the Marine Corps—new tactical combat vehicles, artillery, and supply support systems, among others—may increase significantly the size of the force to be carried in amphibious ships. Moreover, some of the forces needed to support an amphibious assault, such as naval guns, hospital ships, and mine countermeasures ships, have declined to levels that may be too low.

In the past several years, CNA has examined such specific issues as these:

- Whether the Navy should replace conventional landing craft with air-cushion craft, which offer more speed, longer range, and greater tactical flexibility, but at higher cost
- Which type of new assault landing vehicle the Marines should buy—a fast, expensive one; a slow, less-expensive one; or an even less expensive vehicle that would have to be carried ashore on landing craft
- Whether the Marines should replace current assault helicopters with new helicopters of conventional design or more exotic aircraft offering more speed at higher cost
- What new types of amphibious ships the Navy should buy, given present plans for the forces they are to carry.

In view of CNA's background of research into amphibious warfare, the Navy and Marine Corps turned to the organization for an analysis of the direction to follow in modernizing amphibious forces, and for an assessment of the adequacy of the forces for support of amphibious operations. CNA's analysts dealt with all the force elements needed to carry out a large-scale amphibious assault: the Marine assault force, amphibious ships, ship-to-shore vehicles, mine countermeasure forces, fire support weapons, logistic support forces, and

combatant ships for protection against attacks by submarines, aircraft, and missiles.

The study group estimated the effect of new Marine Corps equipment on the size of the future (1990) Marine Amphibious Forces (MAFs) to be carried in amphibious ships. The 1990 MAFs were found to be considerably larger than the present MAF: 3 to 9 percent more personnel, 13 to 20 percent more vehicles, 50 to 60 percent more cargo, and 40 to 60 percent more helicopters. The cumulative effect of these increases on requirements for amphibious ships had not been recognized. Ways to reduce the size of future MAFs are now being studied by the Marine Corps.

The study evaluated the mix of amphibious ships that had been planned for the next three decades. The current LHA was found preferable to the LHDX that the Navy had proposed as the general-purpose amphibious ship of the future. The LHDX has since been redesigned extensively for greater compatibility with the MAFs of tomorrow.

In the course of the study, a new ship concept—the LTAX—was developed. The LTAX is a modified version of the TAKX, the commercial ship to be procured for prepositioning Marine Corps equipment and supplies. Like the TAKX, the LTAX is assumed to be built to commercial standards by the Maritime Administration. The LTAX could provide amphibious lift for Marine forces at roughly half the cost of ships built to standard Navy specifications.

CNA analysts also identified a preferred mix of helicopters, landing craft, and amphibious assault vehicles for moving Marines and their equipment to shore. They found that an equal-cost tradeoff of some helicopters for additional amphibious ships would lead to more effective landing operations.

The study group also examined the ability of the Navy and Marine Corps to prepare for and conduct the various stages of a large-scale amphibious assault: assembly of amphibious ships and movement to the amphibious objective area (AOA); protection of ships enroute to the AOA; preparation of the AOA by preassault bombardment and minesweeping; assault against enemy forces by the MAF; and logistic support for forces ashore and afloat. Analyses in all these areas

revealed inadequacies that must be corrected if the nation is to have a potent amphibious force in the decades ahead.

How to Deploy Marines

In 1979, CNA evaluated a new concept for deploying Marine forces to places where they would not encounter opposition before their units were assembled ashore and combat-ready. The concept called for prepositioning of heavy equipment and supplies on ships in forward areas, and for airlifting troops and helicopters from rear areas, on short notice. The ships and the lift aircraft would converge on a trouble spot, and combat units would assemble.

Partly on the basis of CNA's evaluation, the concept has been adopted. Twelve to fifteen ships called Maritime Prepositioning Ships (MPSs), will be obtained, and equipment for three reinforced Marine brigades—part of the Rapid Deployment Force—will be stored in them.

The Navy and Marine Corps later asked CNA to look into possible uses of the MPSs in conjunction with traditional amphibious assault forces in situations ranging from unopposed landings to landings against stiff opposition. The CNA analysts concluded that amphibious assault forces could, if necessary, seize the facilities needed to land MPS forces. Amphibious assault units could also provide MPS forces with communications, transportation, and medical support. MPS forces, on the other hand, would reinforce a Marine landing force substantially.

Because adequate airfields may not be available where needed, logistic requirements for the airlift may be difficult to meet, and other demands may reduce the amounts of airlift available to MPS forces, the study team also considered ways to improve the flexibility and responsiveness of the present MPS concept, which relies heavily on airlift.

The analysts concluded that the best hedge against a shortfall in airlift would be to locate MPSs with Marine units, for possible transport of troops and helicopters, as well as equipment and supplies. The analysis showed that increased reliance on sealift would give operational commanders more flexibility and, in most cases,

deliver combat-ready Marine brigades faster than the airlift-MPS combination.

Control Systems for Marine Forces

Three studies of control systems, completed by CNA in 1981, played a part in Marine Corps decisions about continuing to develop new, automated systems.

The systems are among several that make up the Marine Tactical Command and Control Systems (MTACCS). They include:

- A planning system to help ground and air commanders and their staffs allocate forces
- An information storage and retrieval system for the intelligence staff (those who collect, process, and interpret information about the enemy)
- A system that locates both ground and air units and reports their positions to a central facility
- Systems to deal with the control problems associated with aircraft, air defense missiles, and artillery.

About the system for planning, the Marines asked how it would affect the outcome of battle. CNA, accordingly, adapted its model of amphibious warfare to account for the effects of more timely information on a commander's allocation of forces and, in turn, on the effectiveness of his forces. The study compared the gain provided by the system with the gain that would result from spending the same money on additional combat forces. On the basis of CNA's analysis, the Marine Corps decided to continue developing the system and is considering how quickly to field the system.

Space-Based Navigation for the Navy

A new, highly accurate worldwide navigation aid- called the Navstar Global Positioning System, or GPS for short—will become available to all the armed forces in 1985. The Navy must soon decide how many sets of equipment to buy and how to distribute them among Naval forces. In particular, it must determine what aircraft to equip with GPS.

At the Navy's request, CNA studied three issues: how GPS would enhance naval capabilities in a variety of missions, the merits and costs of alternative procurement programs, and the savings that could result from phasing out present navigation aids when GPS becomes available.

The study concluded that GPS would improve substantially the capabilities of Naval aircraft to deliver both bombs and mines. It also found that the system would enhance the Navy's minesweeping capabilities and could reduce the amount of sweeping needed to clear a channel if both minesweeping and transiting ships were equipped with GPS.

Tethered Air Vehicles As Sensor Platforms

A relatively new weapon in the Navy's arsenal is the antiship cruise missile. Harpoon is in the fleet now, and Tomahawk is in development. With these weapons, a ship can attack enemy ships that are well beyond the horizon. To attack at such long ranges, however, the firing ship must first detect the enemy and then pinpoint it accurately enough to direct a cruise missile to fly to it.

But the ship's sensors cannot normally "see" beyond the horizon. Sometimes, an airplane or helicopter can fly out to look for enemy ships and tell the cruise-missile ship where to fire. But aircraft are not always available.

One suggestion for dealing with the problem was to send up a lightweight, unmanned—and presumably inexpensive—air vehicle and tether it to the ship. The vehicle would carry sensors, such as radar or passive radio-frequency detectors, high enough to extend the ship's horizon. Some in the Navy opposed the idea, believing that a tethered vehicle would interfere with operations rather than enhance them. To help decide whether to develop these air vehicles for fleet use, the Naval Sea Systems Command asked CNA for an analysis of their potential usefulness and cost.

The study team first identified three types of air vehicles that might be suitable for the purpose: a rotary-winged autogyro, a kite-like parafoil, and a blimp-like aerostat. The analysis focused on these questions:

- Can tethered air vehicles fly high enough and carry enough equipment to detect targets at or beyond the minimum ranges required for Harpoon and Tomahawk?
- Can ships with cruise missiles be configured to operate tethered air vehicles without displacing important existing equipment?
- Can the air vehicles have enough stability and endurance to be tactically useful?

The study team also estimated how much it would cost to develop, procure, operate, and support tethered platforms.

The analysis found that, of the three kinds of tethered air vehicles, only the aerostat had suitable flight qualities. Aerostats, however, tend to be either too large to fit on cruise-missile ships or too hard to inflate and handle at sea without extensive and costly modification of the ship. CNA therefore recommended that the Navy not try to develop tethered air vehicles.

MANPOWER AND MATERIAL READINESS

Forecasting the Supply of Navy Recruits

In 1980, CNA began to look for the cause of the decline in Navy enlistments in 1977-79. At the request of the Office of the Secretary of Defense, the scope of the study was broadened to include similar analyses for the other armed services and to estimate the effects of the loss of GI Bill benefits on enlistments. By the time of completion in 1981, the study provided forecasts of enlistments for all four services, through 1990.

The study team estimated the effects on enlistment of such factors as unemployment, civilian and military pay, GI Bill benefits, federal youth programs, recruiters, Navy advertising, and size of population. Regression analysis was applied with annual data for 1976-80 on enlistment contracts in the Navy's 43 recruiting districts. The analysis showed that:

- Unemployment, by itself, has only a small effect on supply. During an upturn of the economy, such as that of FY 1978, unemployment falls and civilian pay rises. Together, these fac-

tors cause the enlistment supply to decline, but most of the reason is that civilian pay rises faster than military pay. Thus if military pay keeps up with civilian pay, cyclical fluctuations in supply can be reduced substantially.

- The loss of GI Bill benefits in 1977 led to a steep decline in supply. The declines were largest for the Army, probably because it offers shorter enlistment terms.
- Youth programs of the Employment and Training Administration (ETA) reduce supply slightly; student-aid programs of the Department of Education have no effect.
- Recruiters have a positive effect on supply. Not only is supply increased by a service's own recruiters, it is also increased by the recruiters of the other services. Thus, rather than compete for a fixed supply of potential enlistments, recruiters actually expand the supply for all services.

The analysis also yielded conclusions about the relative costs and effectiveness of various enlistment incentives. A GI Bill with the same provisions as the Bill that expired at the end of 1976 would be less efficient than enlistment bonuses for increasing the supply of enlistments. For small expansions of supply, both these alternatives are more expensive than recruiters and advertising. But the productivity of advertising falls quickly; it cannot, therefore, be relied on to generate large increases in supply.

The study also concluded that, throughout most of the 1980s, the services will be able to attract about 25 percent more high-quality recruits than in FY 1980. This increase in supply will occur despite the small, negative effect of the decline in the military-eligible population. The Navy and Air Force should have no problems in meeting their overall recruiting goals; the Army and Marine Corps will experience small shortfalls because of increases in their quality requirements. These forecasts assume that the services will get a 14.3 percent across-the-board pay raise in FY 1982, and that, from then on, military pay will keep up with civilian pay. The forecasts also assume that recruiting resources are maintained and that proposed cuts in ETA expenditures do take place.

To make sure that military pay keeps up with civilian pay, CNA recommended tying the military pay of enlistees to the civilian

earnings of young people, from year to year. CNA also recommended adjusting the services' recruiting resources to the unemployment rate and the level of federal youth programs. Finally, the Army and Marine Corps should receive small increases in recruiters and bonuses above the levels now programmed.

Maintaining Recruiting Standards

The job of a military recruiter is not easy. Every year he must persuade a specific number of young people to enlist in the armed services. Success or failure in meeting his quota is critical to a recruiter's career. He is, in fact, under considerable pressure.

To qualify for military service, a recruit must meet prescribed physical, mental, and moral standards. Sometimes a recruiter who is finding it hard to meet his quota may try to bend the standards and enlist recruits who are unqualified.

One area in which standards are bent is mental aptitude. Every recruit must pass the Armed Services Vocational Aptitude Battery (ASVAB). In an effort to meet their quotas, some recruiters have coached prospective recruits in the ASVAB questions. Unqualified persons have thus entered military service, where they tend to perform poorly.

CNA has been engaged in a long-term effort, consisting of several separate projects, all designed to minimize the effects of coaching on the ASVAB. Procedures have been developed for identifying recruits and recruiters involved in coaching. New forms of ASVAB, in which coaching is harder, have been designed and developed.

CNA has developed an internal consistency check that identifies recruits and recruiters who have a high probability of being involved in coaching. As a result of investigations triggered by the check, several hundred recruiters have been relieved from duty.

Because of CNA's work in this area, fewer unqualified personnel will be enlisted. Preliminary indications suggest that coaching is no longer a serious problem.

How Changes in Pay Affect Navy Reenlistments

CNA developed the Annualized Cost of Leaving (ACOL) model to estimate the effects of changes in military compensation on the size and composition of the Navy enlisted force. The ACOL model does this by relating reenlistment rates to the differential between military pay and the civilian pay that enlistees could earn by leaving the military. The model translates a change in military compensation into a change in reenlistment rates and, then, into a profile of the Navy's enlisted force by military occupation and length of service.

ACOL has been used extensively by manpower planners and compensation managers in both the Navy and the Office of the Secretary of Defense. In 1981, both organizations requested that CNA evaluate the accuracy of ACOL's projections and, if necessary, refine the model to improve its accuracy.

ACOL projections of the enlisted force for 1978-1980, based on data through 1977, were compared with the projections of an earlier CNA model—PROPHET—and with actual experience for 1978-1980. Because PROPHET does not adjust reenlistment rates according to changes in relative military pay—and because military pay declined by 5.9 percent relative to civilian pay during 1978-80—PROPHET overpredicted the size of the enlisted force by more than six percent. ACOL was accurate to within four percent.

CNA also developed two refinements that make ACOL more accurate. First, the effect of civilian unemployment on the reenlistment rate was incorporated into the model. When civilian jobs are scarce, military service looks better, and the reenlistment rate goes up.

Then, the effect of first-term reenlistment bonuses on the second-term reenlistment rate was incorporated into the model. Bonuses paid at the end of the first term of service induce some reenlistments by people who would not have reenlisted otherwise. These people are less likely to reenlist at the end of their second term.

ACOL now accounts for both civilian unemployment and the effects of first-term bonuses on reenlistments. The resulting estimates are almost error-free.

Are Larger Aircraft Squadrons More Efficient?

An aircraft carrier usually operates with two squadrons of fighter aircraft and two squadrons of light-attack aircraft onboard. Each squadron now consists of 12 aircraft. A few years ago, a study commissioned by the Secretary of Defense suggested that carriers should, instead, operate with one squadron of 24 fighter aircraft and one squadron of 24 light-attack aircraft. The Navy asked CNA to evaluate the proposal.

The CNA study examined the effects of consolidation on:

- Personnel requirements and retention
- Material condition of squadron aircraft
- Squadron management.

The CNA study team worked with the Navy to estimate the manning of consolidated squadrons. Billets with annual costs amounting to more than $30 million could be eliminated by consolidation.

Because consolidation would reduce opportunities for promotion and command, more people would leave the Navy. The bonuses required to retain these personnel would partly offset the savings from billet reductions, but the net savings would still be substantial.

Using a simulation model of squadron operations, the study team estimated the effects of manning reductions on the material condition of aircraft and, in turn, on their sortie rates. The results indicated no significant differences between present and consolidated squadrons. This finding does not suggest, however, that consolidation should be adopted, despite its lower costs. Sortie rates are only a partial indicator of combat performance. Performance in combat also depends on the ability of squadrons to operate under pressure and to execute their missions. Consolidation dilutes the ratio of management personnel to subordinates and may, therefore, dilute the overall quality of performance in combat.

The study team could not quantify the effects of consolidation on combat performance. They therefore recommended that the Navy test consolidation before instituting it.

Specifically, they recommended testing the effects of consolidation on a pair of light-attack squadrons. Because light-attack squadrons have fewer personnel than fighter squadrons, management problems arising from consolidation are likely to be less serious. The results of this test may indicate whether new types of light-attack aircraft should be organized into consolidated squadrons as they are brought into the Navy. The results should also show whether a test of consolidated fighter squadrons would be worthwhile.

How to Estimate the Operating Costs of Naval Bases

Every year, the Navy spends over $2 billion on maintenance of its foreign and domestic shore bases, transportation and security for them, and administrative services, health care, and recreation for base personnel and their dependents. These base operating support (BOS) costs are in addition to the direct costs associated with the missions of the "tenants" of Naval bases—ships, aircraft squadrons, test and development activities, and so on.

The Office of the Secretary of Defense (OSD) has been applying a simple measure of efficiency in base operations: Bases with a high BOS cost per mission person are candidates for budget cuts. Congress used this method to cut the budgets of several military bases in 1977. Until recently, the Navy has lacked the data needed to test the validity of the method.

In 1977, OSD began an annual compilation of data. The report lists BOS costs and dozens of physical and personnel characteristics of the largest 150 Naval installations in the fifty states. CNA, applying statistical regression techniques, analyzed data for 1979 and developed a cost-estimating relationship for BOS spending. (The relationship proved to be a good predictor of 1980 costs, as well.)

The study team found that 90 percent of the variations in BOS cost across the sample of 150 bases could be accounted for by five explanatory variables: number of military personnel, number of civilian personnel, total square footage of building area, acreage of land, and number of BTUs of energy consumed yearly. The close relationship between these variables and BOS cost is explained by the general nature of BOS activities. The amount of maintenance required to keep a building in good repair depends primarily on the size of the

building. In a similar fashion, services provided depend mainly on the number of people supported.

The study team went on to illustrate a practical application of the cost-estimating relationship. It was first used to estimate an expected level of spending for each Navy base. The estimates were then compared with actual expenditures. Bases with large differences between expected and actual spending were listed in the final report of the study, with a recommendation that the Navy carry out more detailed analyses to determine whether the differences could be explained by special conditions. If the differences could not be explained, a shift of funds from the "over-spenders" to the "under-spenders" could be expected to increase the overall efficiency of the shore establishment. The Navy has begun its detailed analysis and has found that several cases of "over-spending" were actually matters of gross misreporting of data. A more reliable data base has thus become an unexpected benefit of the study.

Analysis of data for 30 Naval air stations revealed no correlation between OSD's simple ratios and the estimates of spending derived by CNA's method. Therefore, the study team has recommended to OSD that it abandon its simple indicator of efficiency, and use a cost-estimating relationship derived by statistical analysis, instead.

Cost Differences Between Public and Private Shipyards

One problem that is faced by every firm is choosing the efficient combination of inputs to use in producing its output. A competitive market will automatically provide incentives to encourage efficient production. It is sometimes argued that these incentives operate with less force in the public sector.

The repair of Naval vessels is one type of production that is performed in both the public and private sectors. In a study done for the Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics), CNA compared the costs of overhauls in Naval and private shipyards. Specifically, the study analyzed overhauls of the Sturgeon class of nuclear attack submarines between 1971 and 1979.

For the most part, the study group found no significant differences in costs between Naval shipyards and private yards. There were,

however, several instances in which Naval yard costs were significantly higher than private yard costs. A likely reason for higher costs in Naval shipyards is wage rates. There may also be a difference in overhaul quality, but no such difference showed up in the measures of postoverhaul material condition that were examined.

The study found, however, that the overhauls take significantly longer in private shipyards than in Naval yards. Thus, for the Sturgeon class, the number of operational submarines was higher when overhauls were conducted in Naval shipyards.

One way of attaining this greater number of operational submarines, while conducting overhauls in private shipyards, is to buy additional submarines and pay for their operation. Adding this "opportunity cost" to the cost of shipyard work, the study group found that, on average, the cost of Sturgeon-class overhauls was higher in private shipyards than in Naval shipyards.

NON-DEFENSE RESEARCH

Using Quit Rates to Help Set Government Pay

Generally, in a free-market economy, the pay of workers is based on the value of the goods and services they produce. Because the government does not sell most of the services it provides to the public, their value is hard to estimate. It is, therefore, hard to determine what employees should be paid. The government, consequently, tries to set its salaries to equal what is paid for comparable work in private employment. There are indications that trying to equalize compensation is a mistake and that government pay levels are too high. One indication is that quit rates are considerably lower in the government than in the private sector.

One reason for the lower quit rate in the government is that the government is such a large employer. Large firms have lower quit rates, probably because they offer opportunities for transfer and promotion. As part of a further examination of use of the quit rate to measure pay comparability, CNA was asked to relate quit rates to the size of firms.

CNA's analysis of this question made use of a simple model of labor market behavior in which some workers accept low pay while

searching for higher paying jobs, and firms with low turnover costs offer low pay and have high quit rates. This model determines the pay level that will minimize the sum of an employer's turnover and compensation costs, for a given rate of output.

The study showed that even when firm size is taken into account the quit rate in the government is lower than the rate for equivalent work in the private sector. The difference in quit rates suggests that government workers are paid, on average, about 15 percent more than their private sector counterparts. This finding is in line with the results of other studies, but it must be considered tentative until other factors that influence the quit rate have been considered.

How Work Tests Affect Job Search

A person claiming unemployment insurance (UI) benefits must meet criteria regarding prior earnings and reason for loss of employment. Once qualified, a claimant must satisfy a "work test" to continue receiving benefits. A work test determines whether a claimant is searching for work.

An earlier study by CNA showed that small increases in the stringency of work tests (higher denial rates) caused relatively large reductions in benefit payments. The question remained whether the higher denial rates were inhibiting claimants from effectively searching for work and, in that way, reducing the ranks of eligible claimants.

In 1981, CNA completed a study of the matter, drawing on the work and claims histories of over 1,000 persons in Arizona. The study examined the effects of variations in stringency among local UI offices. Both the direct and indirect effects of denials were analyzed.

The analysis of direct effects produced clearcut results. Legitimate UI recipients—those who want to work—were unlikely to be denied benefits.

The analysis of the deterrent effect on those not denied benefits was less clearcut. The deterrent effect seemed to be large. This finding, however, was based on econometric procedures that are subject to various sources of bias; the precise magnitude and significance of the effect is uncertain.

ORGANIZATION

The organization of CNA is depicted on page 58. The three operating groups—the Operations Evaluation Group, Naval Studies Group, and Marine Corps Operations Analysis Group—which conduct the Center's defense research, and the Public Research Institute, which conducts non-defense research, are supervised by the Office of the President. Administrative support and computing services are provided by the Office of the Vice President for Finance and Administration. The Board of Overseers regularly reviews the quality of CNA's research and management. (See section VI of this report for a description of the Board's responsibilities and membership.)

OFFICE OF THE PRESIDENT

The *President* of CNA is responsible to the Board of Overseers and the University of Rochester for all of CNA's activities. He selects the management, organizes the Center's activities, sees to the quality and pertinence of its work, makes certain that it meets its contractual and security obligations, and sets its policies and budgets. The President attends to external relations: with the Department of the Navy, with the broader community of national security analysts, and with the analytical profession generally.

The *Director of Review* monitors the quality of CNA's research for the President. He follows CNA's studies and reviews the finished products to see that CNA's work meets the University's standards of analytical quality and that the results are so presented as to be clear and useful to decision-makers.

The *Director for Naval Matters*, a senior Navy captain, is assigned to the Center by the Scientific Officer for CNA (Op-090), with the concurrence of the President of CNA. The DNM has administrative responsibility for the Operations Study Group (OSG).

The OSG comprises the 23 Naval officers and four enlisted personnel assigned to CNA as working members of the analytical and support staffs. They are selected on the basis of military experience and performance, as well as academic background (16 of the officers and one of the enlisted personnel hold advanced degrees). Nine additional officers are authorized in the group, but because of Navy manning shortages these billets are now vacant. In 1981, however, 12 officers were assigned for various periods of temporary duty to assist in CNA's research and gain analytical experience.

Though the members of OSG report to the Director for Naval Matters for administrative purposes, they work side by side with civilian professionals. While they are in OSG-CNA, their work is directed by the President of CNA, not by the Navy.

Aside from the valuable analytical contributions of the members of OSG, they provide the rest of CNA's research staff with practical experience, technical knowledge, and a user's point of view. They are quick to point out any discrepancies between theoretical analyses and the realities of naval operations and warfare. Furthermore, the OSG program provides practical training in applied analysis for these personnel. They, as well as the Navy itself, will benefit from the experience when they move on to higher positions.

OPERATING GROUPS

Each of the three operating groups has its own fields of specialization.

Operations Evaluation Group (OEG)

OEG has the longest history of any of CNA's operating groups, dating back to 1942, when it was known as the Anti-Submarine Warfare Operations Research Group. At first, the group helped devise ways of combating the German U-boat attacks on U.S. shipping. The group's success in this endeavor led to a broadening of the types of naval warfare to which it applied quantitative analysis. A main result of these wartime contributions was the permanent establishment of OEG, with the support of Admiral of the Fleet Ernest J. King.

The field program, also born of World War II, remains an important part of OEG's activities. OEG's field representatives return after one- or two-year tours with the fleet, to be replaced by others from the Washington area office. There is thus a continuing infusion of practical experience into CNA's formal studies. This is matched by a counter-infusion of up-to-date knowledge of analytical techniques into OEG's field program. CNA and the Navy have long felt that this program leads to far more practical and realistic analyses than would be possible if the analysts never left their desks in Washington. OEG has a professional staff of more than 60, of whom 37 are assigned to these Navy commands:

Atlantic Area

Brunswick, Maine
Commander, Patrol Wings, Atlantic

Newport, Rhode Island
President, Naval War College

New London, Connecticut
Commander, Submarine Development Squadron Twelve

Patuxent River, Maryland
Air Test and Evaluation Squadron One

Norfolk, Virginia
Commander-in-Chief, Atlantic/U.S. Atlantic Fleet
Commander, Naval Air Force, Atlantic
Commander, Surface Warfare Development Group
Commander, Tactical Wings, Atlantic
Commander, Operational Test and Evaluation Force

Charleston, South Carolina
Commander, Cruiser-Destroyer Group Two
Commander, Mine Warfare Command

Jacksonville/Mayport, Florida
Commander Cruiser-Destroyer Group Twelve
Commander, Sea-Based ASW Wings, Atlantic

European Area

London, England
Commander-in-Chief, U.S. Naval Forces, Europe

Gaeta, Italy
Commander, Sixth Fleet

Naples, Italy
Commander, Battle Force, Sixth Fleet
Commander, Submarine Force, Sixth Fleet
Commander, Maritime Surveillance and Reconnaissance Force, Sixth Fleet
Commander, Area Antisubmarine Warfare Forces, Sixth Fleet

Pacific Area

Whidbey Island, Washington
Commander, Medium Attack Tactical Electronic Warfare Wing, Pacific

Moffett Field, California
Commander, Patrol Wings, Pacific

Pt. Mugu, California
Air Test and Evaluation Squadron Four

China Lake, California
Air Test and Evaluation Squadron Five
Lemoore, California
Commander, Light Attack Wing, Pacific
San Diego, California
Commander, Naval Surface Force, Pacific
Commander, Antisubmarine Warfare Wing, Pacific
Deputy Commander, Operational Test and Evaluation Force, Pacific
Commander, Fighter Airborne Early Warning Wing, Pacific
Commander, Tactical Training Group, Pacific
Pearl Harbor, Hawaii
Commander-in-Chief, Pacific Fleet
Commander, Third Fleet
Commander, Submarine Force, Pacific
Kamiseya, Japan
Commander, Patrol & Reconnaissance Force, Seventh Fleet
Yokosuka, Japan
Commander, Seventh Fleet
Subic Bay, Philippines
Commander, Carrier Striking Force, Seventh Fleet

The main emphasis in OEG remains what it was in the earliest days of the organization- getting the most out of the forces at hand and sending scientists to sea to help in that process. OEG is concerned with how best to use the Navy the nation has today and is committed to for the next few years. This is the concern not only of OEG's field representatives, but also of its Washington-based analysts, who both conduct their own research and augment the efforts of their colleagues in the field.

As the Navy has changed, so has OEG, especially in the kinds of projects it undertakes. But OEG's mode of operation has not changed significantly since its inception. OEG pioneered in the development of military operations research techniques and in creating the close working relationship between civilian scientists and Naval personnel that continues to this day.

Over its lifetime, OEG has trained hundreds of operations analysts. Its "alumni" are scattered throughout the government, the academic world, and industry; both directly and indirectly, the organization's efforts continue to benefit the nation.

Naval Studies Group (NSG)

NSG, which was formed as fiscal year 1981 ended, represents a consolidation and expansion of the activities of the Naval Warfare Analysis Group (NAVWAG) and the Institute of Naval Studies (INS). Both of these groups had been part of CNA since its establishment in 1962. In general, NAVWAG's studies involved the evaluation of alternative combatant forces and related systems being considered for the mid-range and long-range future. INS research had focused on politico-military affairs, strategic planning, manpower, and logistics, concerns that cut across many types of warfare.

The 60 analysts assigned to the Naval Studies Group will conduct research in these areas:

Naval Strategy. NSG's program of strategic studies is aimed at helping the Navy to develop and refine a strategy that is consistent with defense policy and national objectives. This task requires research in such subjects as:

- Soviet strategy and capabilities
- Relations with U.S. allies and their military contributions to common defense
- Domestic and international economic problems and prospects.

Naval Applications of Advanced Technology. Research in this area is intended to help the Navy identify and exploit the potential of new technology--bridging the gap between basic research, on the one hand, and warfare planning, on the other. This program will deal with such technologies as those of advanced computers, communications techniques, space sensors and weapons, long-endurance aircraft, and directed-energy systems.

Long-Term Naval Force Planning. This program will assess systematically the costs and effectiveness of systems. It will analyze trade-offs that the Navy leadership must consider in programming and in long-term force planning. CNA's recent assessment of the balance of amphibious warfare forces suggests the type of research to be done in this area. (See "Shaping Tomorrow's Amphibious Forces" in section II of this report.)

Naval Warfare. The purpose of the activities in this program will be to enhance understanding of the conduct and course of naval warfare. The program should lead to a fundamental rethinking of how naval combat might evolve during a war, as a result of such factors as:

- Advanced Soviet forces, including new battle cruisers and aircraft carriers
- Space systems for intelligence, surveillance, targeting, and command and control
- Longer-ranged naval weapons, including cruise missiles
- Long-range, land-based aircraft
- Electronic warfare, cover and deception, and decoys.

The research is aimed at completely rethinking and reorganizing the analysis of naval campaigns and assessments of naval capabilities.

Manpower, Support, and Readiness. Research in this area will continue CNA's efforts in manpower, training, logistics, reliability and maintenance, and supply. A special effort will be made to relate expenditures on these support activities to the readiness of the Navy's combat forces.

Management Processes. This program will examine the Navy's methods of allocating and managing its resources. Research will deal with such issues as R&D strategies, acquisition management, implementation of decisions, and cost overruns.

Special Studies. Research in the six areas described above will be conducted under CNA's prime contract. Defense research that is funded by separate contracts will be done in the Special Studies Program.

Every six months, each program will be reviewed with Navy sponsors, to assess its progress and make sure that it is directed at the most important problems facing the Navy.

Each of the programs will yield four kinds of research products:

- Two to four formal studies a year
- Short-term assistance to the Navy on urgent problems

- Information about technical and analytical developments outside CNA that are of importance to Navy planners
- An annual conference that will bring together Navy people, CNA researchers, and outside experts to discuss research results and research needs in each area of inquiry.

Each program will have its own small group of recognized experts from outside CNA, to advise on the design and conduct of the program. Each such group will include a member of CNA's Board of Overseers, a highly qualified former military leader, a civilian representative of the appropriate research community, and recognized experts from academia and industry. These advisory councils will play an important role in linking CNA to sources of new ideas and new information.

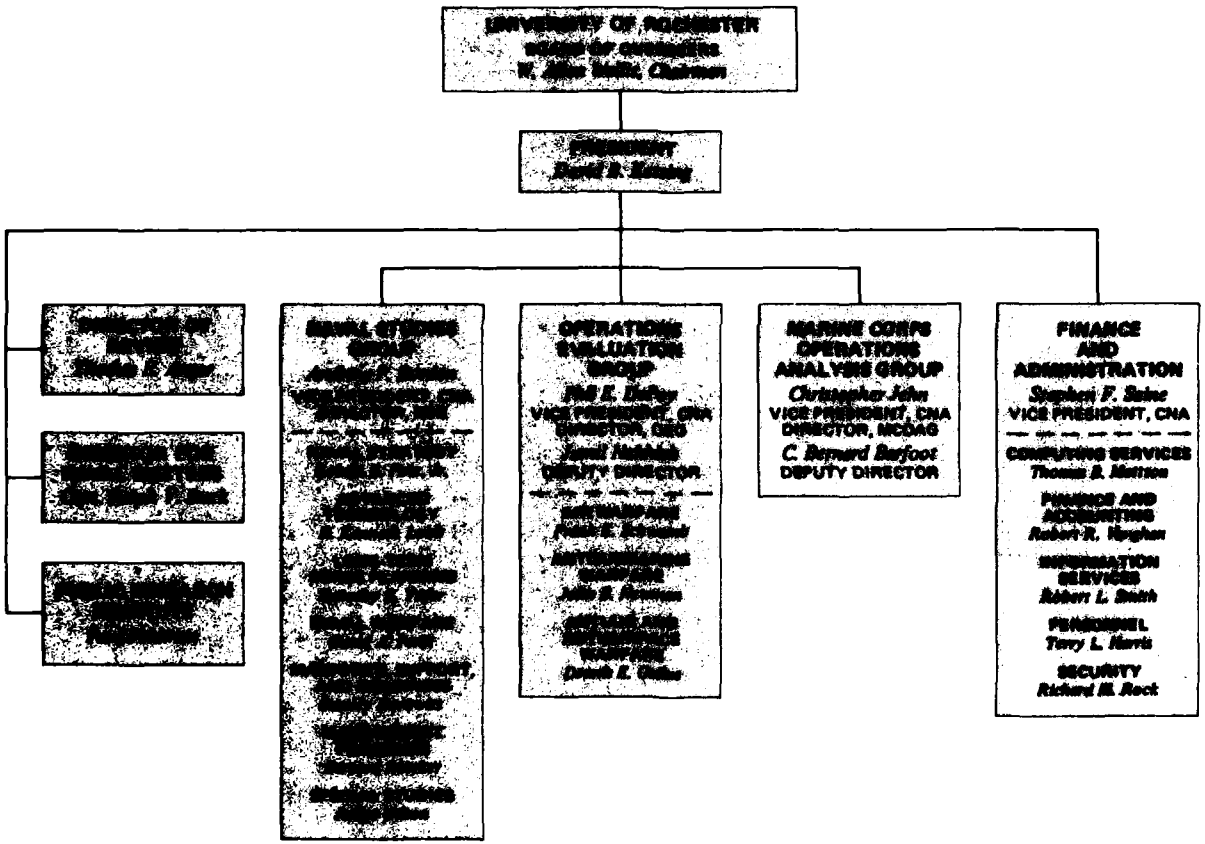
Marine Corps Operations Analysis Group (MCOAG)

MCOAG was established as a CNA operating group in 1965. Its professional staff of more than 20 analyzes a wide range of problems for Marine Corps Headquarters in Washington and for commands in the field. MCOAG research involves such elements of warfare as amphibious assault, ground combat, tactical air warfare, and antiair warfare, as well as such related areas as manpower and logistics.

For its analyses of amphibious warfare, MCOAG has developed a series of computer models that design alternative forces and evaluate them. One model creates equal-cost mixes of amphibious ships, landing craft, assault vehicles, and helicopters. These forces are then evaluated by means of a large-scale computer model that simulates the major combat activities of an amphibious assault. This model has been used to evaluate mixes of tactical aircraft, new infantry organizations, and concepts of operations. The set of models has been used to evaluate equal-cost mixes of amphibious ships and the landing craft, helicopters, and amphibian vehicles that carry Marines ashore.

MCOAG, like CNA's other operating groups, has done some work in direct response to Congressional concerns. One such analysis has been the evaluation of lightly armored vehicles that the Marine Corps might use for antitank and infantry support missions. MCOAG analysts have also looked into the value of new intelligence and command and control systems, and the benefits of the increased speed offered by advanced-technology aircraft for amphibious assault.

THE ORGANIZATION OF CNA



Analyses of Marine Corps manpower problems account for another significant portion of the MCOAG study program. Emphasis has been placed on development and analysis of mental aptitude tests for prospective recruits, and relationships between individual scores on these aptitude tests and performance in the service. MCOAG's manpower research is being broadened in scope to include analyses of the supply of Marine recruits and the retention of career personnel.

More than half of MCOAG's analysts have served as field representatives at Marine Corps and Navy commands. The group maintains field billets at the headquarters of the Fleet Marine Forces in Honolulu, Hawaii, and Norfolk, Virginia, and at the Marine Aviation Weapons and Tactics Squadron in Yuma, Arizona.

OFFICE OF THE VICE PRESIDENT FOR FINANCE AND ADMINISTRATION

The Vice President for Finance and Administration is responsible for all matters relating to financial and contractual management, for programs affecting physical security, for compliance with the Industrial Security Regulations of the Defense Investigative Service, for publication and distribution of research reports, and for the operation of the Personnel and Computing Services departments.

The directors of five departments report to the Vice President for Finance and Administration.

Computing Services is responsible for operation of the computer center, for centralized programming, and for a proper match between the capabilities of computing resources and the needs of CNA users. The Computing Services staff provides computing, consulting, and programming support for both the CNA research program and the administrative departments.

Finance and Accounting provides cost and management accounting reports, financial management services, contract administration, and procurement services.

Information Services has two main functions in support of research: (1) acquisition, dissemination, and control of research materials, and

(2) production and distribution of completed research reports. This department is also responsible for managing CNA's library.

Personnel provides recruiting, interviewing, and testing services, maintains personnel records, administers the salary and fringe benefits program, and manages CNA's Equal Employment and Affirmative Action programs.

Security assures compliance with the Industrial Security Regulations of the Defense Investigative Service and is responsible for providing building maintenance and office service support.

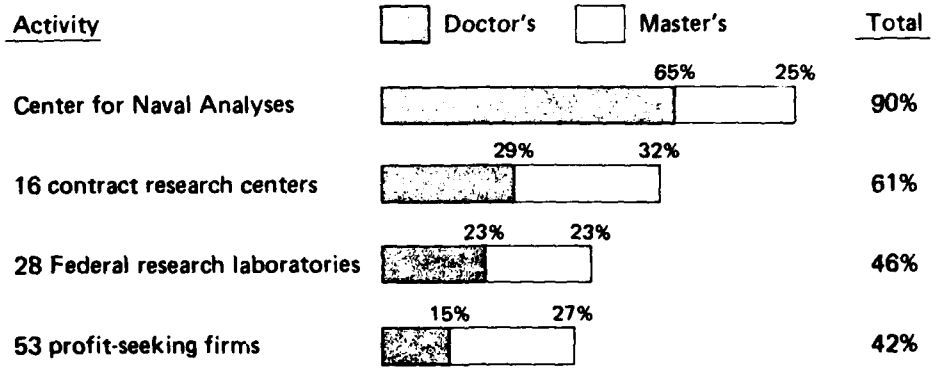
PERSONNEL

Management by the University of Rochester gives CNA a unique advantage in attracting and retaining a professional staff of high quality. The recruiting program is designed to draw new talent from top-rated colleges and universities across the nation and to attract experienced professionals with a record of accomplishment in defense research.

STAFF COMPOSITION

CNA's professional staff is well suited to conducting research of critical importance to the nation's defense. The staff is highly educated and experienced; most of its members hold advanced degrees. In fact, the proportion of staff members holding advanced degrees is much higher at CNA than at similar research organizations:

POSTGRADUATE DEGREES
(Proportion of professional staff, 1981)*



*Source: "National Survey of Compensation Paid Scientists and Engineers Engaged in Research and Development Activities," Battelle Memorial Institute, Columbus, Ohio, November 1981.

The quality of the postgraduate education received by CNA's staff is also high. CNA actively recruits at many of the finest universities in the country and supports continuing postgraduate education of staff members through its program of tuition assistance and professional development.

In addition to the ability to attract professionals of high quality, CNA also retains its experienced analysts. Many of them have spent

one or more tours in field assignments at Navy and Marine Corps commands, where they have acquired first-hand knowledge of the problems they are called upon to analyze at CNA-Washington. This is the background of the CNA professional staff:

- Average postgraduate education — 3 years, 11 months
- Average career experience
  - Total — 10 years, 10 months
  - Directly related to CNA research — 8 years, 11 months
- Proportion with field experience — 44 percent
- Average cumulative time in the field* — 3 years.

These are the disciplines represented in the professional staff:

	Number	Fraction of staff
Physics and chemistry	56	30%
Mathematics and statistics	38	21%
Economics, business, and finance	37	20%
Engineering	18	10%
Operations research	12	6%
Political science and international relations	4	2%
History	4	2%
Psychology and sociology	4	2%
Other	12	7%
TOTAL	185	100%

SALARIES

The Vice Presidents approve all offers of employment and all actions affecting professional staff salaries. Any salary above the maximum paid under the Civil Service General Schedule ($50,112 in October 1981) must also be approved by the Executive Committee of the CNA Board of Overseers and by the Navy's Contracting Officer.

**Of analysts with field experience.*

To make sure that CNA salaries are competitive, CNA's management analyzes salary survey data drawn from a large national sample of scientists and engineers by degree, specialty, and level of experience. This information is supplemented by informal exchanges with organizations conducting research similar to CNA's. Individual salaries and contributions to the research program are reviewed every year.

EQUAL OPPORTUNITY

CNA has long supported the principle of equal opportunity, regardless of race, creed, color, national origin, sex, age, or physical handicap. To that end, CNA has established policies and practices in conformity with federal legislation. The main purposes of CNA's Affirmative Action Program are: (1) to make sure that, within each sector of the labor market drawn on by CNA, minorities and women are represented on the CNA staff to the same degree as they are in the sector as a whole, and (2) to provide all employees with opportunities for training and advancement. CNA continues to be dedicated to these objectives.

FINANCIAL INFORMATION

The Center for Naval Analyses is not a corporate entity; it operates as an affiliate of the University of Rochester. All contracts, bank accounts, and other legal agreements are carried in the University's name and are executed by designated officials of the University. Within this framework, CNA maintains an autonomous financial system for payroll, tax reporting, purchasing, cash management, and all standard accounting functions.

Funding

All of CNA's funding is provided through cost-reimbursable contracts and grants arranged with agencies of the federal government. Of the funding received during FY 1981, contracts with the Department of the Navy accounted for 97 percent. In lieu of a management fee, five percent of the funding awarded to CNA is allocated to the University of Rochester for unclassified research devoted to areas of potential interest to the Navy.

Property and Equipment

CNA owns no physical assets. Under the terms of CNA's contract, all property and equipment is either leased or purchased for the account of the federal government. As a result of this contract provision, and in the absence of a contract fee, CNA has no net worth or retained earnings.

Cash Requirements

Because CNA lacks other sources of capital, the organization's contracts call for the Navy to provide working capital through an advance funding account. Advances are drawn weekly on the basis of anticipated expenditures and offset by monthly vouchers.

Financial Controls

Financial control of CNA's operation is achieved through a system of budgeting and expense monitoring. At the start of the fiscal year, an operating budget is developed for each division within CNA. The division must then perform its assigned tasks within that budget. Monthly expenditures are closely monitored, and budgets are revised whenever there is a significant change in CNA's funding.

All contract expenditures are reviewed by the staff of the Vice President for Finance and Administration to insure compliance with federal regulations and contract provisions. Expenditures for travel, supplies, equipment, and consultants are documented by requisitions and approved by CNA's management. Major purchases must be approved in advance by the Navy's Administrative Contracting Officer. Further, CNA's financial system is audited regularly by the Defense Contract Audit Agency and the University's public accountant (Peat, Marwick, and Mitchell).

The following tables outline the financial status of CNA.

FUNDING IN FY 1981
(Thousands of dollars)

Source of funds	
Defense:	
CNO/CMC study program	$12,351
Tactical Development and Evaluation	2,350
Other programs	593
Total defense	$15,294
Non-defense:	
Department of Labor	$ 30
National Science Foundation	196
Total non-defense	$226
Total FY 1981 funds available	$15,520
Funds carried forward from FY 1980	1,069
Total funds expended	$16,589
Application of funds	
CNA program costs	$15,820
On-campus research	769
Total funds applied	$16,589

STATEMENT OF COMPARATIVE FINANCIAL CONDITION
30 September 1981 and 30 September 1980

ASSETS

	1981	1980
Current assets		
Cash	$ 191,336	$ 189,710
Receivable (note 1)	143,958	163,130
Travel advances and prepaid items	580,254	346,591
Advances – U.S. Navy	241,859	515,035
Total current assets (note 2)	$1,157,407	$1,214,466

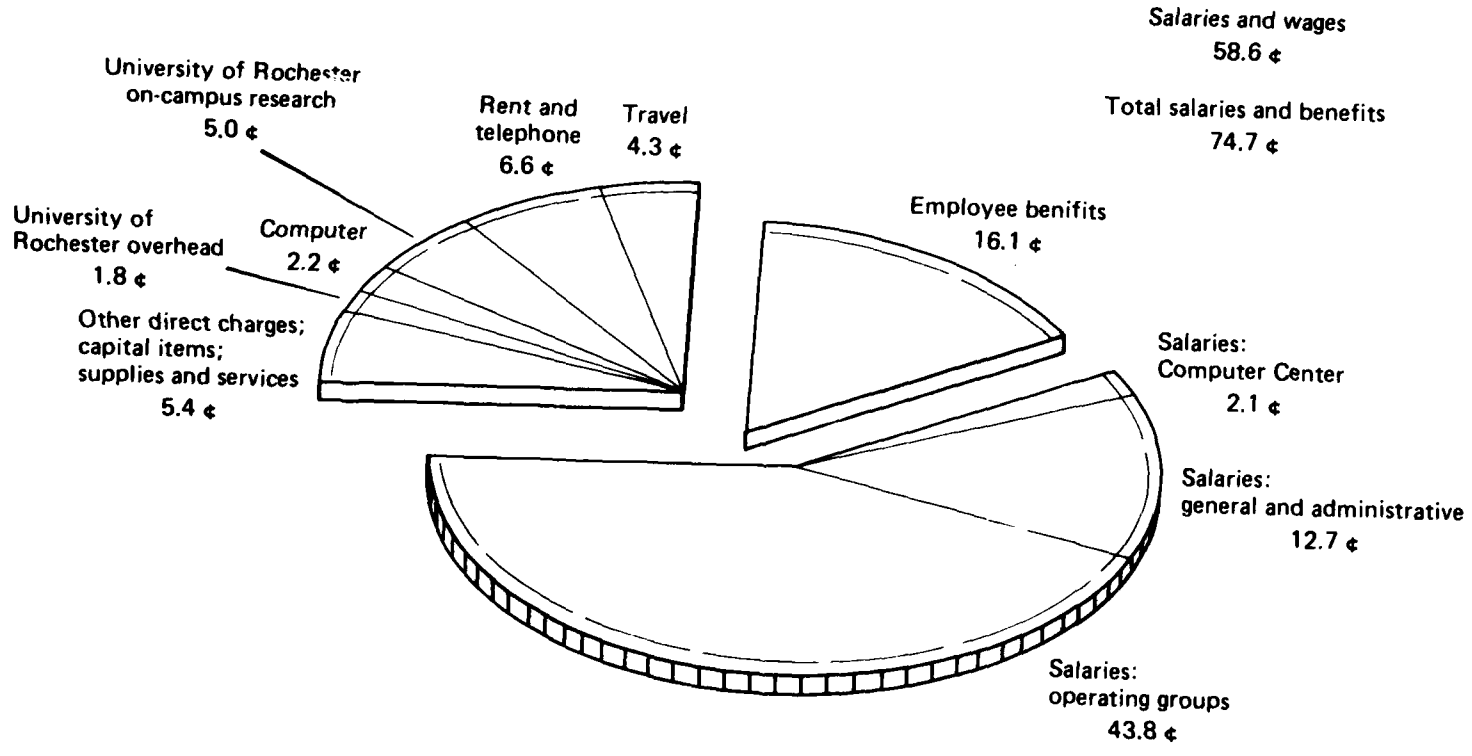
LIABILITIES AND RESERVE FOR DISALLOWANCES

Current liabilities		
Accounts payable	$ 197,534	$ 420,079
Payroll taxes and other withholdings	145,092	74,551
	$ 342,626	$ 494,630
Other liabilities		
Accrued annual leave	772,643	684,187
Unbilled labor adjustments	42,138	35,649
Total other liabilities	$ 814,781	$ 719,836
Total liabilities	$1,157,407	$1,214,466

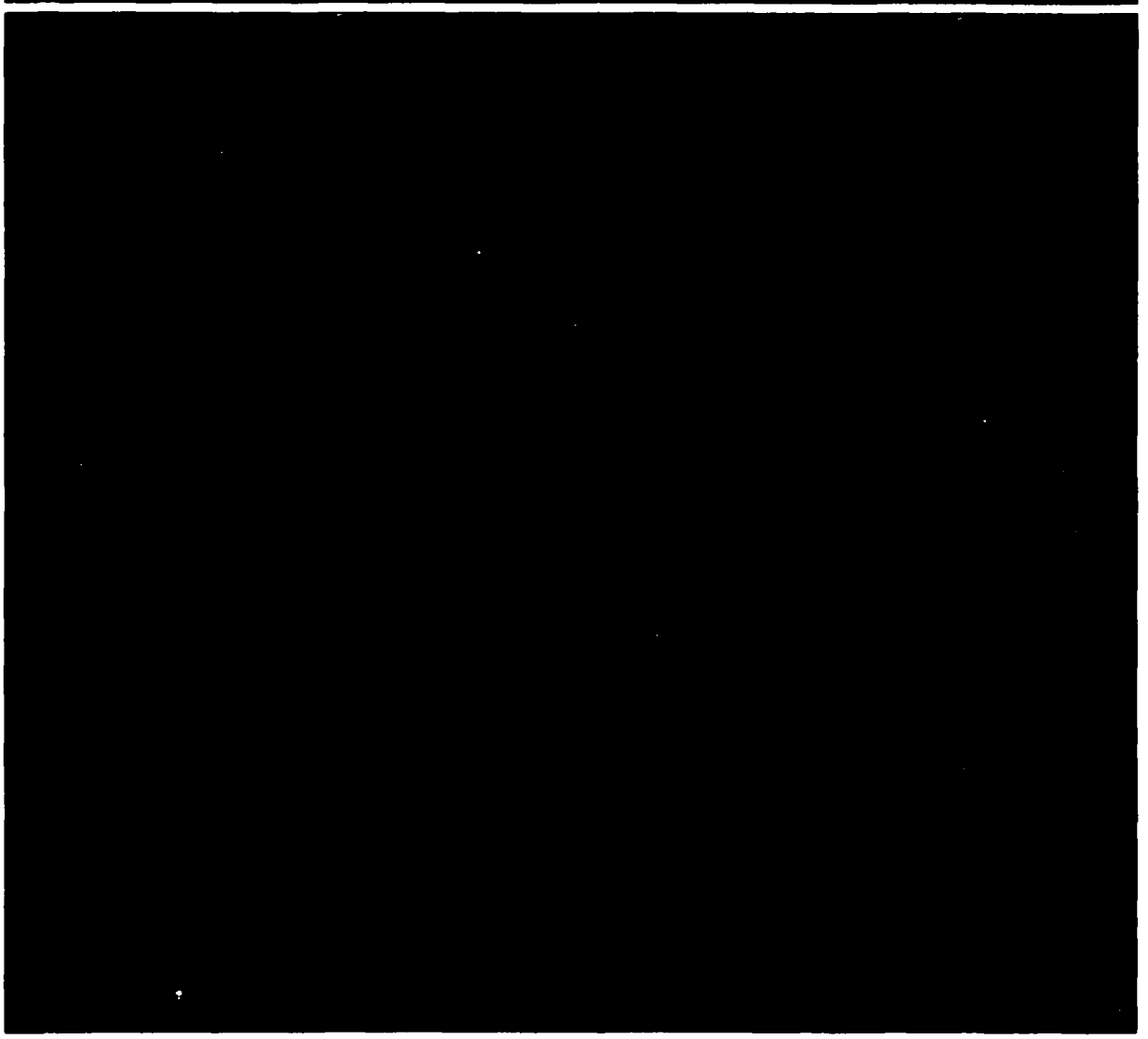
NOTES:

1. Government agencies account for over 95 percent of all receivables.
2. CNA has no physical assets. Property and equipment constitute direct charges, with title vesting in the government.

APPLICATION OF THE RESEARCH DOLLAR IN FY 1981



BOARD OF OVERSEERS



The Board of Overseers of the Center for Naval Analyses has the responsibility for formulating overall policy for CNA, maintaining high standards of professional competence and integrity in CNA's work, and reviewing the general management policies and personnel of the organization.

At three regular meetings a year, the Board reviews the work of CNA. At one of these meetings, held at the Center's offices, the methods and results of major research are presented in detail to the Board. Four to six projects, covering classified work done in the Washington area, are reviewed.

A second meeting is usually held near a CNA field office. This gives the Board an opportunity to review operational analyses done for the operating forces of the Navy and Marine Corps.

Unclassified research for Navy, Marine Corps, and non-defense sponsors is discussed with the Board at a meeting held at the University. The Board also reviews some of the basic research that is conducted on campus, under the University's contract for management of CNA.

MEMBERS

W. Allen Wallis
Chancellor of the University of Rochester

Martin J. Bailey, Professor of Economics, University of Maryland. Former Assistant for Southeast Asia Forces, Department of Defense

Andrew P. Borden, Vice President, Naval Studies Group, the Center for Naval Analyses. Former Chief Scientist, System Analysis Division, Office of the Chief of Naval Operations.

Kenneth E. Clark, Professor of Psychology and former Dean of the College of Arts and Sciences, University of Rochester. Member of the Army Science Board. Former consultant to the Office of Science and Technology.

Adm. C. Donald Griffin, USN (Ret.), former Deputy Chief of Naval Operations. Former Commander in Chief, U.S. Naval Forces, Europe. Former Commander-in-Chief, Allied Forces, Southern Europe.

Donald K. Hess, Vice President for Campus Affairs, University of Rochester. Former Director, U.S. Peace Corps. Former Director for Program Management, Advanced Research Projects Agency.

Arthur Kantrowitz, Professor of Engineering and Senior Lecturer in Engineering Sciences, Dartmouth College. Former Chairman and Chief Executive Officer of Avco Everett Research Laboratory. Honorary Trustee of the University of Rochester.

David Kassing, President of the Center for Naval Analyses. Former Director of Research of the President's Commission on all All-Volunteer Armed Force. Former Director of Naval Forces Division, Office of the Assistant Secretary of Defense (Systems Analysis).

William H. Meckling, Dean of the Graduate School of Management, University of Rochester. Former member of the National Science Board. Former Executive Director of the President's Commission on an All-Volunteer Armed Force. Former President of the Center for Naval Analyses.

Elliott W. Montroll, Professor, Institute for Physical Science and Technology, University of Maryland. Former Vice President, Institute for Defense Analyses.

William A. Nierenberg, Director of the Scripps Institution of Oceanography. Chairman, NASA Advisory Council. Member, National Academy of Sciences.

David S. Potter, Vice President and Group Executive in charge of the Public Affairs Group of General Motors. Former Under Secretary of the Navy. Member of the National Academy of Engineering.

Frank P. Sanders, Vice President of the Signal Companies, Inc. Former Under Secretary of the Navy.

Robert L. Sproull, President and Chief Executive Officer of the University of Rochester. Trustee of the University of Rochester. Former Chairman, Defense Science Board. Former Director, Advanced Research Projects Agency.

Brian J. Thompson, Dean of the College of Engineering and Applied Science, University of Rochester. Former Director of the Institute of Optics, University of Rochester.

LaRoy B. Thompson, Senior Vice President and Treasurer of the University of Rochester. Honorary Member (and former Chairman) of the Board of Associated Universities, Incorporated.

Adm. W. F. A. Wendt, USN (Ret.), former Deputy Chief of Naval Operations. Former Commander in Chief, U.S. Naval Forces, Europe.

Albert Wohlstetter, Senior Fellow of the Hoover Institution, Stanford University. Former member of the professional staff and Research Council, the Rand Corporation.

PAST MEMBERS

Carl Amthor (1969-72)
Charles J. DiBona (1967-73)
McCrea Hazlett (1967-71)
Hubert Heffner (1973-75)*
Robert Loewy (1967-74)
Stephen Lukasik (1975-77)
David A. McBride (1967-78)
Russell Murray 2nd (1974-77)
Patrick Parker (1967-72)
Clarence L. A. Wynd (1968-81)

**Deceased*

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